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# PRESERVATION OF SOIL MONOLITHS [1 2]

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## Itroduction

Ever since the origin of the present day conception of soils it has been desirable for soil research workers and teachers to secure soil samples which retain as nearly as possible their natural characteristics as they exist in the field. Samples for analysis can be taken from each successive horizon but they do not show the sequence of layers and transition from one to the other nor the natural structure of the soil. Many attempts have been made to mount an undisturbed cross section of the soil or a soil profile. Various methods have been used.

The author's first experience in assisting to prepare a soil monolith was by using a glass cylinder about two and one-half inches in diameter and three and one-half feet long. A pit was dug about four feet deep and the cylinder was held along the vertical cross section of the soil. After plugging the lower end of the cylinder with cotton batting it was filled with soil material from the exposed soil surface so that the soil in the cylinder corresponded with each horizon as it occurred in the natural soil profile. Monoliths from three soil series were prepared in this way (Plainfield, Fox and Berrien). These were prepared primarily for an exhibit but were used subsequently for classroom work.

The next method used was developed from an idea obtained from an exhibit at the Soils Department of Ohio State University. A number of galvanized iron trays were made four feet long by four inches wide by one and one-half inches deep and panes of heavy glass cut to fit neatly on the inside. After digging a pit a little over four feet deep a profile was taken out in sections with a long narrow spade and placed in a tray. The soil surface in the tray was then cut down with a trowel until the glass fitted neatly. The glass was then puttied in air tight leaving the soil with its natural moisture content. This method has been fairly satisfactory for illustrating differences in color, texture, etc., and sequence of horizons but it does not show up the natural structure of the soil.

Laterly we have used the method suggested by Harper (*1*) or a method modified from it, using less expensive materials with just as satisfactory results.

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[1]Paper presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Twelfth Annual Convention at the Manitoba Agricultural College, Winnipeg, June 16, 1932.

[2]This short paper may be regarded as a progress report on some work which the author has been doing as a member of a Committee of the American Soil Survey Association, on Exchange of Soil Profiles. One of the first duties of this committee was to devise a suitable method of securing and mounting a soil profile which would be applicable under varying conditions, so that a uniform exchange could be worked out among the institutions interested.

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## Review of Literature and Methods

Harper (*1*) has reviewed much of the literature on this subject. He discusses Glinka's method of forcing a metal tray into a vertical soil face.

A somewhat similar but cumbersome method is described by the U.S.D.A. Bureau of Soils (*2*). The profile is kept moist by capillary action by packing the base of the box with sphagnum moss which is kept moist.

Chapman (*3*) has suggested a method which is based on the same principles. A hole nine inches in diameter and four feet deep is dug with a post hole auger. One side of this is made flat with a square-pointed spade and a metal tray forced into this flat face by means of automobile jacks.

These methods are fairly satisfactory for many soils which are not stony but profiles obtained in this way must be handled very carefully to preserve the natural characteristics of the soil.

Bushnell (*4*) has described a method using pad glue. A strip of canvas is glued to a vertical soil face. After the glue has set the sample or profile adhering to the glue is broken off from the bank. Profiles taken by this method are comparatively light and easy to handle. If handled with a reasonable amount of care they are quite durable. This method is quite satisfactory on many types of soil but is not altogether satisfactory on some sandy soils or other soils which are very granular on drying.

There have been some other methods described which are based on the same general principles.

One of the latest and most generally applicable methods is that of Harper (*1*) in which he treats the vertical soil face with a dilute lacquer solution, allows it to set and then fastens a board to it with tar or pitch. The sides are then cut away and the mounted profile removed from the bank.

## Cost of Materials

This latter method has been found to be quite satisfactory under varying conditions but the cost of materials is rather high, particularly when used by novices. According to prices quoted at the local hardware store, clear lacquer retails at ninety cents per pint or one dollar and seventy-five cents per quart and the lacquer thinner at one dollar per quart, which makes the cost per monolith about seventy-five cents to one dollar and twenty-five cents. The tar or pitch is quite cheap.

The author tried out several materials to replace the lacquer and lacquer thinner. One of the two most satisfactory of those tried out was a homemade lacquer made by dissolving discarded motion picture film, or ordinary photographic film, with the chemical coatings removed, in acetone. The other and least expensive (fifteen cents per monolith) was sodium silicate dissolved and diluted in water.

## Method of Procedure and Equipment

### MATERIALS USED

Spade, preferably square pointed.
Smoothing tool.
Portable gasoline heater (or other heater).

Small toy watering can.
One pound tin of water glass (sodium silicate) diluted with three times its volume of water.
An old kettle for melting the tar.
A wide paint brush.
A large spoon.
A small quantity of asphalt tar with melting point of about 100-125°C. (That used for repair work on highways is quite satisfactory).
One board 4 feet × 1 inch × 5½ inches (longer if desired).
Two strips 4 feet × ⅜ inch × 2 inches.
One strip 6 inches × ⅜ inches × 2 inches.
One dozen 1 inch screws.
One screw driver.
One steel spatula or knife.

PROCEDURE

The procedure for mounting the soil monolith is as follows:—

1. Select a suitable location where the profile development of the soil is characteristic of the type of soil you wish to mount. If a suitable roadside cut or other cross section exposure is not available dig a pit about 4½ feet deep.
2. With a smoothing tool smooth an almost vertical section of the bank about 6 inches wide and a little over 4 feet deep. The board should fit neatly on this smoothed surface. (If there are any small depressions such as might occur in stony soils they can be filled with a little soil material soaked with sodium silicate solution).
3. With the small toy watering can slowly sprinkle the sodium silicate solution on the surface smoothed to fit the board, allowing it to soak into the soil.
4. Allow this to set for about twenty-four hours and protect it from the direct rays of the sun if very hot.
5. Melt the tar, paint one side of the board and apply a liberal coating of the hot tar to the previously prepared section of the bank.
6. With the gasoline heater, or blow torch if available, heat the tar on both the bank and the board until it just begins to run.
7. Place the tarred side of the board on the bank and hold firmly for a minute or so until the tar congeals.
8. With the steel spatula or knife cut away the soil so as to leave the sides of the mounted soil monolith at right angles to the board.
9. Fasten the ⅜ inch strips to the sides and bottom of the base board.
10. Dig away some of the soil from behind and remove the mounted monolith, being careful not to let a large clod or stone slip down behind and unduly disturb the exposed surface of the monolith.
11. Pick off all loose material down to the required depth, invert the monolith and shake it or tap it lightly. The surface should not be cut or scraped but rather left with the natural cleavage faces exposed.

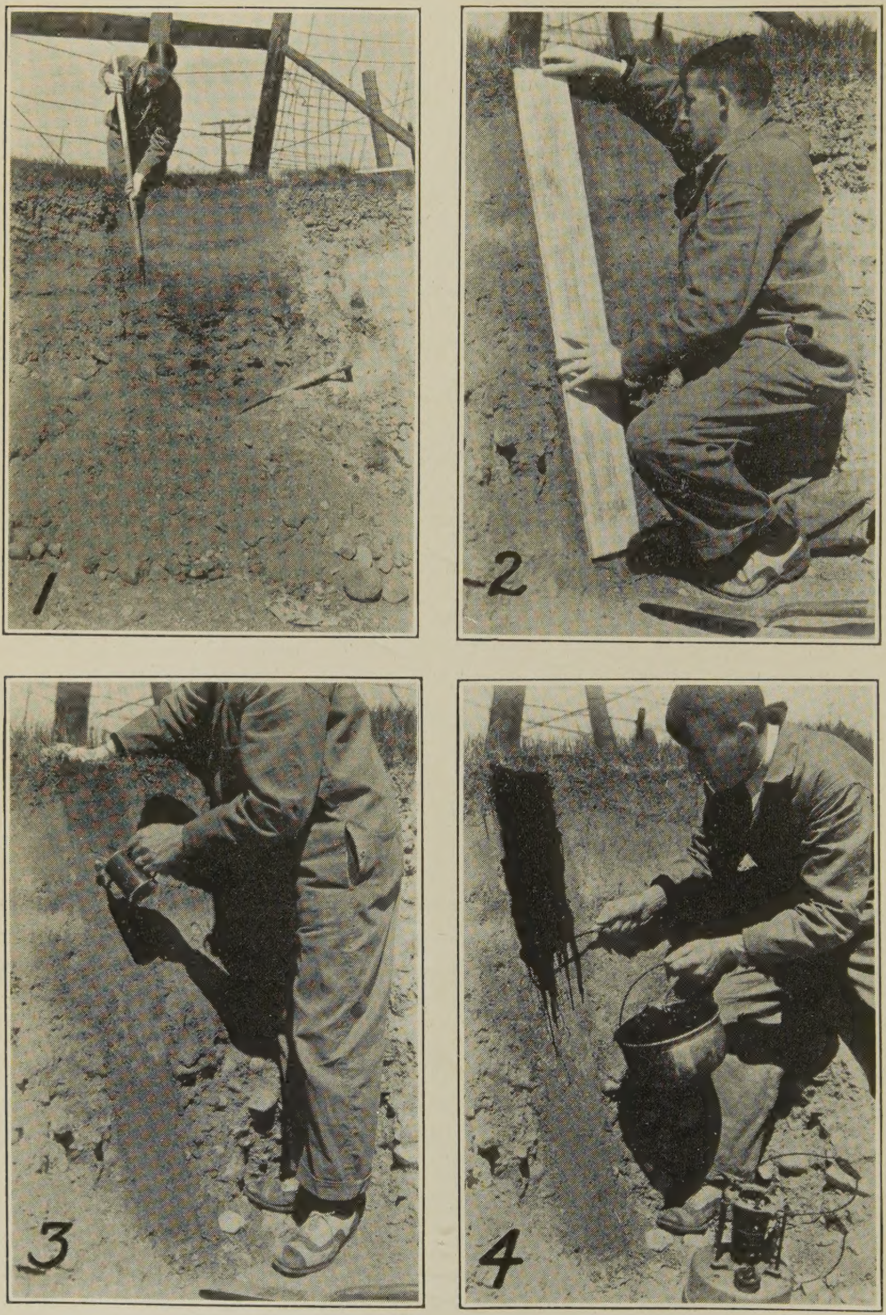


PLATE I. 1. Freshly exposed profile. 2. The board should fit neatly on the smoothed surface. 3. Sprinkling on the sodium silicate solution. 4. Covering the surface with hot asphalt tar (24 hours later).

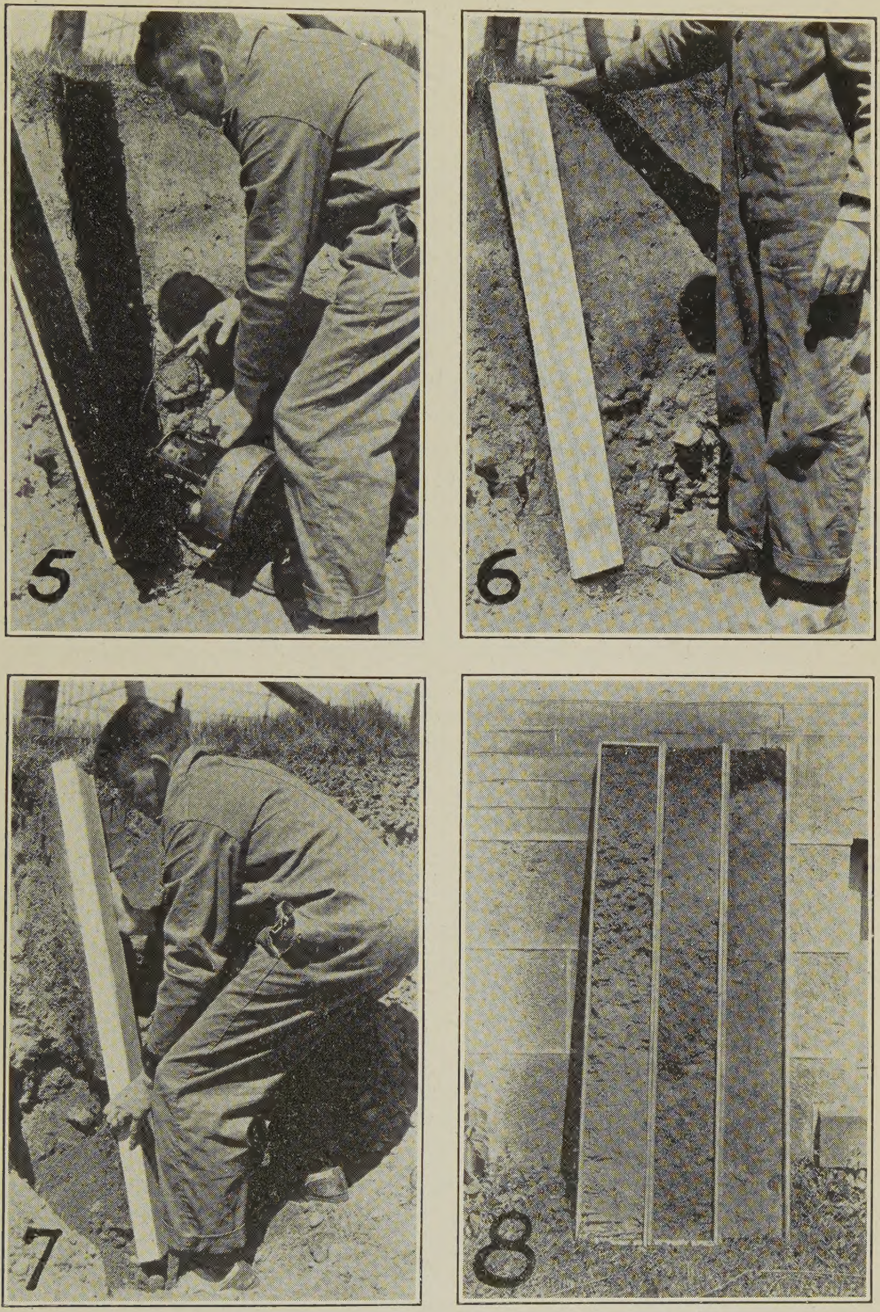


Plate II. 5. Reheating the tar so that the board will get a firm grip. 6. The board fastened firmly to the bank. 7. Breaking the mounted monolith away from the bank, after the strips have been fastened to the sides. 8. The finished product: Haldimand silt loam (a lacustrine soil); Bellefontaine loam (a morainic soil); Rubicon sand (an outwash soil).

## Discussion

This method gives promise of being quite satisfactory under a wide range of conditions, and the cost is small. The monoliths obtained present a natural appearance, are comparatively light in weight and can be handled with a fair amount of freedom.

Like the Harper method, it requires two trips to the selected location but if the distance is excessive a profile of sufficient dimensions can be taken in a trough or box according to method used by Glinka and others and mounted in the laboratory. To do this the soil should be fairly moist so that it will not crumble easily and disturb its natural structure.

Mounted soil monoliths should have a fair degree of permanency. This method, of course, has not yet stood the test of time but the following quotation from Rogers Manual of Industrial Chemistry is quite assuring—"Water glass is used to render tissues non-inflammable, to protect wood and porous stone, to fix pigments on calico and color on mural paintings, to make artificial stone, and also to cement glass and pottery."

## Summary

1. Methods for the preparation and preservation of mounted soil monoliths have been studied.
2. Materials which could be used to bind together soil particles and aggregates of soil particles have been investigated, keeping in mind their cost.
3. A method for mounting soil monoliths has been described, using water glass and asphalt tar, both of which are cheap and quite satisfactory for the purpose.

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# LEACHING OF MINERAL MATTER IN SOME ALBERTA SOILS

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The main soil belts of Alberta are the brown soils, the black soils and the grey wooded soils. Each one of these soil belts occupies certain large areas in this province, the brown soil being the characteristic soil of the southeastern part, the black soil of a large area in south central Alberta and the grey wooded soil of a very large area in the northern half of the province. Other soil belts occur but these are in reality transition soils between the three principal belts mentioned above. A recent publication by Wyatt and Newton (*10*) contains a map that shows the location and extent of these major soil belts of Alberta.

Field studies had shown that the soils of these three main belts differ greatly in the amount of leaching they have suffered. The main object of this investigation was to make a study of the extent of this leaching in each of these soils, as judged by the translocation of the iron, aluminum, calcium and magnesium within the soil profile. A secondary object was to see if, on the basis of the extent of the leaching of these elements, these soils could be correlated with main soil types in other parts of the world.

## Description of Soils

While many are familiar with the designations accorded by pedologists to the various horizons of the soil profile, still it may be well to briefly review the subject so as to avoid any confusion as to the terms used in this paper.

The A horizons extend from the surface to the bottom of the layer of greatest leaching; the $A_1$ horizon being that one which contains the great bulk of the organic matter, while the $A_2$ horizon is that one which shows the greatest effect from leaching. The B horizons include both the layer in which the greatest accumulation of fine soil particles occur and the lime concentration layer, the former being designated the $B_1$ and the latter the $B_2$.

The soils analyzed in this study are typical of the more mature soils of the three principal soil belts of Alberta. Profiles of two brown soils, three black soils and three grey wooded soils were sampled and analyzed, and the results were averaged for the soils from each belt (see table 1). The following brief description shows the great difference that exist between these three soils. These soils have been described in considerable detail by Wyatt and Newton (*9*) and by Wyatt and Ward (*11*).

The brown soils are characterized by relatively thin A and B horizons with the lime accumulation zone close to the surface. The $A_2$ and the $B_1$ horizons are not always easily distinguished from each other. These horizons are neutral to slightly alkaline in reaction. The $B_2$ usually occurs at less than a foot from the surface.

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The black soils are characterized by a deep, very dark coloured surface layer. This layer, the $A_1$, has an average depth of about ten inches, though it sometimes extends down from the surface for two feet. The $A_2$ and $B_1$ horizons are only occasionally sufficiently well developed as to be easily recognized in the field. These horizons are nearly neutral in reaction. The $B_2$ horizon is quite noticeable in the profile, usually occuring at about three feet from the surface.

The grey wooded soils are characterized by an apparently badly leached zone near the surface. The upper two inches of these soils consist of leaf mold, the $A_0$ horizon. Immediately below this leaf mold lies the $A_1$ horizon, a drab coloured layer one to two inches in thickness. The $A_2$ horizon has the appearance of a badly leached soil. It is a light grey structureless soil with a characteristic ashy appearance. This layer varies from eight to twelve inches in thickness. The $B_1$ horizon under this leached layer is very heavy in texture, in some cases being so refractory as to almost constitute a hardpan. This zone may be several feet thick, the lime accumulation zone being seldom found less than four feet from the surface.

## Methods of Analysis

The soil samples were first fused. For calcium and magnesium the fusion was with sodium peroxide, whereas magnesium nitrate was used to fuse the sample for the phosphorus determination. After fusion the calcium, magnesium and phosphorus were determined in the usual manner. Iron, aluminum and silica were determined by the methods outlined by the A.O.A.C. (*1*).

## Expression of Data

In horizons containing considerable amounts of organic matter or carbonates the extent of leaching of the mineral constituents will be somewhat masked if the data is expressed on the basis of the water free soil, because the mineral matter will be diluted by this material. The full extent of the leaching can best be studied by expressing the data on the basis of the mineral content. The mineral content was taken as that residue which was left after ignition.

## Composition of Alberta Soils

As previously stated the profiles selected in these studies were representative of virgin mature soils of intermediate texture. Under field conditions it is customary to find variations in soil composition for different areas of the same soil. Such variations were found in these studies but are not here shown as only averages are included. The differences in soil composition are much greater for the soils from the different belts than for the different profiles for the same belt. In reality the different profiles from the same belt showed a very striking similarity.

The data in table 1, where average analyses are recorded, show that there are considerable differences in the composition of these different soils. The black soil, in particular differs from the other soils in its lower $SiO_2$ and higher $Al_2O_3$ and $Fe_2O_3$ contents. The brown soil and the grey wooded soil

are more nearly alike in these constituents but there are significant differences even between these soils. The A horizons of the grey wooded soil contain the highest silica and the lowest alumina and iron.

TABLE 1.—*Analyses of Alberta soils. Expressed on basis of mineral matter.*

*Brown soil—Benton district.*

| Horizon | Depth in inches | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $P_2O_5$ | $\frac{SiO_2}{\text{sesqui oxides}}$ |
|---|---|---|---|---|---|---|---|---|
| $A_1$ | 0–5 | 77.5 | 9.19 | 3.45 | 1.35 | 1.12 | .13 | 6.1 |
| $A_2$ | 5–7 | 79.6 | 11.21 | 3.60 | 1.11 | .72 | .12 | 5.4 |
| $B_1$ | 7–10 | 78.8 | 11.59 | 4.15 | 1.62 | .98 | .13 | 5.0 |
| $B_2$ | 10–30 | 72.6 | 10.10 | 4.21 | 7.36 | 2.22 | .13 | 5.1 |
| | | | | *Black soil—Edmonton district.* | | | | |
| $A_1$ | 0–10 | 73.7 | 13.06 | 5.13 | 1.74 | .93 | .32 | 4.1 |
| $A_2$ | 10–22 | 73.5 | 14.40 | 5.88 | 1.21 | 1.20 | .16 | 3.6 |
| $B_1$ | 22–36 | 72.5 | 15.23 | 6.45 | 1.01 | 1.03 | .10 | 3.4 |
| $B_2$ | 36–48 | 69.8 | 12.01 | 5.31 | 3.83 | 1.03 | .14 | 4.0 |
| | | | | *Grey wooded soil—Lake St. Ann district* | | | | |
| $A_0$ | 0–2 | 81.3 | 8.63 | 2.53 | 2.69 | .70 | .33 | 7.3 |
| $A_1$ | 2–4 | 84.8 | 8.46 | 2.53 | .96 | .52 | .12 | 7.7 |
| $A_2$ | 4–14 | 84.2 | 8.53 | 2.84 | .63 | .63 | .07 | 7.4 |
| $B_1$ | 14–44 | 79.9 | 12.46 | 4.41 | .85 | .98 | .06 | 4.7 |
| $B_2$ | 44– | 73.8 | 11.84 | 3.83 | 4.19 | 1.50 | .13 | 4.7 |

The surface horizons have, usually, a higher content of calcium, magnesium and phosphorus than the horizons immediately below them. This is an enrichment due to the fact that plants have drawn these elements from the subsoil and accumulated them at the surface in combination with the organic matter. Thus as far as these three elements are concerned there have been two forces at work in the depletion of the $A_2$ and the $B_1$ horizons, an upward movement due to the above cause and a downward movement due to leaching processes. This upward movement particularly of phosphorus is very noticeable in the highly organic surface horizons of the black and grey wooded soils. It would seem that any movement of this element had been upward. The evidence furnished by the analyses indicated little or no movement downward.

The data clearly show these soils differ markedly in the extent to which they have been leached. The extent of this leaching can be judged both from the depth of the lime carbonate accumulation zone below the surface and the translocation of the iron and aluminum from the elluvial to the illuvial horizons. The extent of this movement of iron and aluminum probably can best be judged by study of the silica—sesquioxide ratio of the various horizons. A comparison of the silica sesquioxide ratio for the various horizons in any one profile should show at a glance the severity of the leaching which that soil has undergone. A fairly constant ratio between these oxides throughout the profile in-

dicates little or no leaching of the iron or aluminum, while a sudden change in this ratio shows that movement of these elements must have taken place.

From the above viewpoints the data in table 1 bring out clearly that the brown soil has suffered little from leaching processes, the grey wooded soil has suffered severely and the black soil to an intermediate extent. The sesquioxides in the brown soil have apparently not been translocated at all while the carbonate horizon occurs at ten inches from the surface and even this comparatively shallow layer has not in many cases been completely leached of its carbonates.

At the other extreme we have the grey wooded soils which have been badly leached. Not only have the carbonates been carried down to a considerable depth but the iron and the aluminum have been translocated to a large measure from all the A horizons, that is, from the upper 14 inches of the soil. While the carbonates of lime and magnesia are fairly readily leached the elements which form sesquioxides are extremely resistant to leaching process. Hence their removal to this extent shows that conditions which favor active leaching in a soil must have been present for a considerable length of time in these grey wooded soils.

As previously mentioned the black soils are in an intermediate position between the other two soils as to the extent of leaching they have suffered. From the viewpoint of carbonate movement this soil is almost in the same class as the grey wooded soil, the lime and magnesia carbonates having been completely removed from the upper 36 inches of the soil profile. On the other hand from the viewpoint of iron and aluminum translocation this soil is more in the class of the brown soil, since sesquioxides have not moved to any great extent. That a movement has taken place is quite apparent but it is small when compared with that which has taken place in the grey wooded soil.

The silica sesquioxide ratios for the profiles of these three soils clearly show at a glance how differently they have been affected by leaching processes. The fairly constant ratios throughout the profiles of the brown and black soils are in striking contrast to the ratios throughout the profile of the grey wooded soil. The great spread in the ratios between the A and the B horizons of the grey wooded soil shows how drastic the leaching has been in this soil.

## Main Factors Causing Differences in Alberta Soils

What has already been written shows that the soils of the three main soil belts of Alberta differ greatly from each other, both in morphological characteristics and in chemical constitution. From our observations these differences appear to be chiefly due to the differences in vegetation that exist between the different soil belts, although climatic differences have also played an important part. Other factors that influence the soil, such as the nature of the parent material and topography, have played but little part in the development of the fundamental differences between the soils of these belts. Similar kinds of parental material and similar topographical features are found in all three of the belts, still

the soils developed are quite different. There is a possibility that the high lime carbonate content of most of the brown soils has slowed up the rate of leaching, although even where the carbonate content is not as high the soil profile is not greatly different from that previously described.

It is not the writer's intention to deal at any length with the effect of climatic and vegetative factors upon the type of soil profile developed. The great effect of these factors upon the development of a soil has been clearly shown by Glinka (*2*), Ramann (*8*) and others. The writer merely intends to point out the differences in these factors in each of the soil belts of the province and to briefly discuss the relative importance of each upon the particular type of soil profile which has been developed in these belts.

At the present time the climate of the region where the brown soils occur differs markedly in two important respects from the climate of the regions where the black and grey wooded soils are found. The average annual precipitation is lower 12-14 inches as against 18 inches for the latter regions and the evaporation is considerably greater in the former region. On the other hand there is no appreciable difference in climate between the black and the grey wooded soil belts in central Alberta, though in the northern part of the grey wooded soil belt the climate becomes drier until the annual precipitation is no greater than it is in the drier part of the brown soil belt. As far as summer temperatures are concerned there is no great difference between any of these areas, the isotherms, running N.W. by S.E. cutting right across the different soil belts.

While the climate differences are only marked in case of the brown soil belt, the natural vegetation differs greatly in each belt. The brown soils occupy the treeless plains, where the dominant growth is the short grasses and the sages. The black soils occur in what is locally known as the "park belt" of the province. This area, in its native state was extensively wooded with poplar and willow, but there was also a heavy grass growth. The grey wooded soils lie in the bush area of the province, a very large area of land, covered with poplar interspersed with spruce, pine and willow. The grass growth is usually very scanty in this area. Lewis, Dowding and Moss (*7*) show that this bush area in Alberta is divisible into two zones, the Northern Coniferous Forest and the Cordillerean Forest. While at the present time the poplar is the predominating species there is a good evidence to verify the suggestion of these authors that the spruce is the climax type of vegetation even in the Cordillerean Forest. There is no doubt that spruce was once much more prominent than it is today.

The differences in climate between the brown soil belt and the other two belts are such that it can be readily seen that climatic factors have played a direct part in the development of the differences between these soils, but in the case of the black and grey wooded soils it is difficult to see how climatic factors have played a direct part in the development of the difference between these two soils, since no appreciable difference in climate exists. It would seem, therefore, that these great differences must be due to great differences in vegetation, differences which today are probably not so clear cut as they have been in the past.

The literature regarding the development of soil profiles has stressed the direct effect of climate as much if not more than the effect of vegetation. It seems quite clear that this is not the case, at least in this province. Here vegetation has been the important factor, for not only is this shown in the case of the grey wooded soils and the black soils but it is also shown in the case of the grey wooded soils in the northern part of the province, and the brown soils in the south. The typical soil of the far northwestern part of the province is little different from the grey soils described in this paper, still the annual precipitation is no greater than that in the brown soil area. The great difference in soils must be due to the fact that one area has been wooded while the other has been grass covered.

## Correlation with the Principal Soil Groups of the World

The Russian system of soil classification (*2*, *6*) based upon the types of soils produced by climatic and vegetative factors has been generally accepted by pedologists, particularly for the classification of soils developed under continental conditions. Since the soils of Alberta have been developed under such conditions, these soils should fit into this classification.

The brown and black soils in Alberta can be classified in this system without difficulty.

The brown soils belong to the group of soils called by the Russian school the chestnut coloured soils. Our brown soils have developed under similar conditions as have the chestnut coloured soils, namely, on open grassy plains under a somewhat scanty rainfall in a temperate climate, and hence these soils have a very similar profile.

The black soils, also, would seem to belong to that well known group of soils—the chernosems. The surface horizon in both these soils is a deep zone, rich in organic matter, the zone of carbonate accumulation occurs at about the same depth in each, and neither show any appreciable movement of the sesquioxides. Both of these soils have developed under about the same amount of precipitation, 16-18 inches and the climate and vegetation is in most respects very similar.

A comparison of the data in table 2 with that in table 1 clearly shows that there are similarities between these soils in so far as leaching processes have affected them. The third layer in the table for the chestnut coloured soils is the carbonate zone, which as in the case of the Alberta brown soils occurs near the surface. The carbonate zone in chernosem occurring at 80 cm. is at about the same depth as the same zone in the black soils in this province. The data clearly show that there has been little translocation of the sesquioxides in any of these soils.

The Alberta grey wooded soils are not as easily classified with this major soil classification scheme as the other two soils as they differ in certain details from any of the principal soil types enunciated by the Russian school. However, their A horizons are so similar to the A horizons of the podsol group that the writer believes that they should be classified as podsols even though they differ in respect to the B horizons, inasmuch

TABLE 2A.—*Analyses of chestnut colored soils*. Data expressed on bases of mineral matter.*

| Depth in inches | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| .2 to 1.6 | 68.42 | 16.36 | 5.55 | 2.67 | 2.33 |
| 2.0 to 4.7 | 68.26 | 16.42 | 6.55 | 2.90 | 1.49 |
| 4.7 to 6.7 | 69.98 | 16.59 | 6.01 | 3.20 | 2.13 |

* Marbutt's translation—Glinka's great soil groups—p. 145.

TABLE 2B.—*Analyses of chernosem*. Data expressed on bases of mineral matter.*

| Depth in inches | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| 0–11.8 | 63.0 | 22.46 | 6.44 | 2.76 | 2.25 |
| 11.8–21.6 | 75.3 | 20.02 | 6.96 | 2.77 | 2.00 |
| 21.6–31.5 | 73.6 | 20.18 | 6.64 | 1.97 | 2.46 |
| 31.5–43.3 | 72.6 | 19.55 | 6.46 | 7.79 | 2.35 |

* Marbutt's translation—Glinka's great soil groups—p. 133.

as in these Alberta soils there is practically always a zone of carbonate accumulation and there is no "orstein" or hardpan layer, a feature which is characteristic of most podsols.

A comparison of the analyses of a podsol, as shown in table 3A with the analyses for the Alberta grey wooded soil in table 1 shows that the A horizons in each have been severely leached and that the extent of the translocation of the iron and aluminum is of nearly the same magnitude. This leaching has been of such a severe nature that the $A_2$ horizon in the grey wooded soils has been almost as well developed as has the corresponding horizon in the podsols. This being the case there seems little doubt but that these grey wooded soils should be classified as podsols, for according to Glinka (*3*) the term podsol is used to designate soils which have a pronounced and well developed, whitish $A_2$ horizon.

The absence of the hardpan or "orstein" layer is not a barrier against classifying them as podsols. To quote Glinka (*4*) "the formation of a hardpan is not found under all podsols by any means. In the true podsols ... the hardpan is often entirely lacking. It follows therefore that for the formation of hardpan other conditions must exist than those which are necessary for the formation of other features of these soils". Such other conditions have been apparently lacking in this province for, while the $B_1$ horizon of the grey wooded soils is a very heavy tenacious layer, it could not be called a hardpan.

The presence of a carbonate horizon in the Alberta soils, a horizon which is absent in the Russian podsols, is not a sufficient reason for excluding these soils from the podsol group. Carbonates are readily leached from any soil providing there is sufficient water percolating through the soil, while other conditions must be present as well as sufficient moisture before any movement of the iron or aluminum will take place. These Alberta soils have developed under a precipitation of 18 inches or less while the podsols of Russia have developed under a precipitation of 35-40

inches. It can be readily seen that from these figures the carbonates could be leached to a much greater depth in these European soils than they could in these Alberta soils where the lower depths of the soil profile is seldom affected by percolating waters. However, from the development of the $A_2$ horizon in each there is no doubt that the same factors have been at work in the development of these soils, factors which have been modified but not materially changed by the amount of moisture available for leaching purposes.

The only other principal soil type that the Alberta grey wooded soils could possibly be correlated with is that of the grey forest soil. The writer believes that such a correlation is impossible. Descriptions of the latter (*5*) show that it has a well developed $A_1$ horizon as compared with a thin poorly developed horizon and the $A_2$ horizon has a so-called nut structure as compared with the structureless $A_2$ horizon of the Alberta grey wooded soils. A comparison of the analyses for these two soils (see table 3B and table 1) shows that they also differ greatly insofar as they have been affected by leaching processes. These differences are sufficient to prove that these soils belong to two distinct types.

TABLE 3A.—*Analyses of a podsol free from hardpan*. Expressed on basis of mineral matter.*

| Horizon | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | $\frac{SiO_2}{\text{Sesquioxides}}$ | $\frac{SiO_2}{\text{Sesquioxides}}$ in Alberta grey wooded soils |
|---|---|---|---|---|---|
| $A_1$ | 76.42 | 15.29 | 1.98 | 4.4 | 7.7 |
| $A_2$ | 78.01 | 14.52 | 2.05 | 4.7 | 7.4 |
| $B_1$ | 67.65 | 18.19 | 4.78 | 2.9 | 4.7 |

*Marbutt's translation—Glinka's great soil groups of the world, p. 78.

TABLE 3B.—*Analyses of grey forest soil*. Expressed on basis of mineral matter.*

| Horizon | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | $\frac{SiO_2}{\text{Sesquioxides}}$ |
|---|---|---|---|---|
| $A_1$ | 80.4 | 11.31 | 3.29 | 5.5 |
| $A_2$ | 77.6 | 11.98 | 4.01 | 4.9 |
| $B_1$ | 76.6 | 12.92 | 3.86 | 4.6 |

* Marbutt's translation—Glinka's great soil groups of the world, p. 96

## SUMMARY

1. The various horizons representing soils of the brown, black and grey wooded soil belts were analyzed for Si, Al, Fe, Ca, Mg, and P.

2. Analyses show that little leaching of any of these elements has occurred in the brown soils. The black soils have been leached of lime, but little movement of the Al or Fe has taken place. The grey wooded soils have been leached to a considerable depth of lime and the Al and Fe has been translocated to a considerable extent.

3. The grey wooded soils are the only soils which have been severely leached.

4. Alberta soil belts can be fairly closely correlated with the Russian system of soil classification.

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# ESTIMATING STATISTICALLY THE SIGNIFICANCE OF DIFFERENCES IN COMPARATIVE FEEDING TRIALS [1]

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It was Davenport who stated that "The most obvious fact about living beings is their variability." And the student of heredity has for many years given considerable thought to the question of variation, but until quite recently relatively little serious attention has been paid to the fact of variation in respect to its effects on the reliability of such averages as are used to express the results of comparative feeding trials.

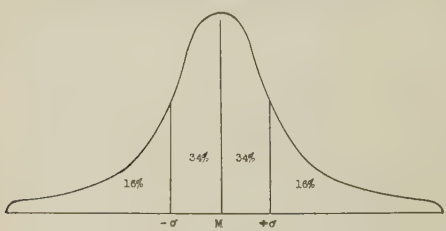
A comparative feeding trial, after all, is but an attempt to determine the relative feeding values of certain feeds or feed combinations, using as measuring sticks groups of live animals whose individual response to the same experimental treatment has been shown to be exceedingly variable. The reliability of the average performance of any group of such animals depends upon two factors, namely, the number of animals involved in the average, and the uniformity with which they react to the experimental treatment. Thus it follows that the significance of the difference observed between the average results of two comparative lots is based on the numbers of animals involved and the variability of their performance.

Tests for the significance of means or mean differences, therefore, require the calculation of some measure of the variation existing within the group contributing to the average. The measure of variability most generally used is the standard deviation expressed by the symbol, sigma ($\sigma$).

## The Standard Error of the Mean

The relation of the standard error of a mean to the problem of testing the significance of such a mean depends on the fact that in a normal frequency distribution the standard deviation defines an interval of which the mean is the mid-point or value and within which 68% of the variates of the population lie, or approximately two out of every three.

By increasing the width of this interval about the mean by multiplying the standard deviation by some quantity, we can divide the curve so that any desired proportion of the variates will fall within (or without) the limits of the adjusted standard deviation. Twice the standard deviation for instance includes 95% of the variates, or all but 5% of them. In a given population, therefore, the chances are 1 in 20 that a variate chosen at random will be found ouside $\pm$ 2 $\sigma$.




Division of Normal Frequency Curve by $\pm\sigma$

(Figures show per cent of observations expected to fall within areas indicated.)

Figure 1.

[1] A paper read before the Eastern Canada Society of Animal Production, Ottawa, July 5, 1932
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Steps in the Calculation of Standard Deviation and Standard Error of the Mean.

1. Sum the variates (X) ........ $\Sigma X$
2. Divide the sum of the variates ($\Sigma X$) by the number (n) to get the arithmetic mean ........ $Mx = \frac{\Sigma X}{n}$
3. Square each variate and add the squared values ........ $\Sigma X^2$
4. Multiply the sum of the variates ($\Sigma X$) by their mean (Mx) and subtract the product from the sum of the squared values $\Sigma X^2 - \Sigma X\ (Mx)$
5. Divide the remainder (in step 4) by one less than the number of variates (n – 1) and extract the square root of the quotient. This gives the STANDARD DEVIATION ($\sigma$) of a single variate within the group ........ $\sigma = \sqrt{\frac{\Sigma X^2 - \Sigma X\ (Mx)}{(n - 1)}}$
6. Divide the standard deviation ($\sigma$) by the square root of the number of variates to get the STANDARD ERROR OF THE MEAN ........ $\sigma_m = \frac{\sigma}{\sqrt{n}}$

The standard error of the mean bears a definite relation to the standard deviation of a population as is evident from the fact that it is calculated by dividing the standard deviation by the square root of the number of variates of the group.

Plus or minus the standard error of a mean defines an interval within which the mean of a second sample of the same population will be expected to fall in 68 cases out of 100. Similarly, only once in 20 cases will the mean of a second sample be expected, by chance alone, to fall outside the limits of twice the standard error of the mean of the first sample; *if both samples really belong to the same population.* By calculating the means and their standard errors for the two groups involved in a feeding trial comparison, it is possible to tell, with a known degree of certainty, whether there is a real difference between them in the item being considered or whether the difference observed might have occurred irrespective of the imposed experimental treatment. The scheme in principle is illustrated in Figures 2 and 3.

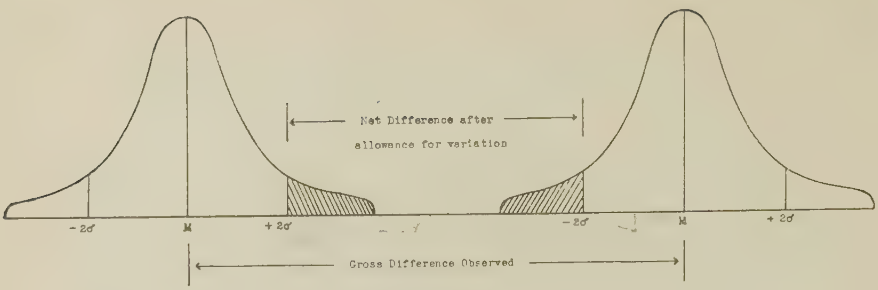



Figure 2.

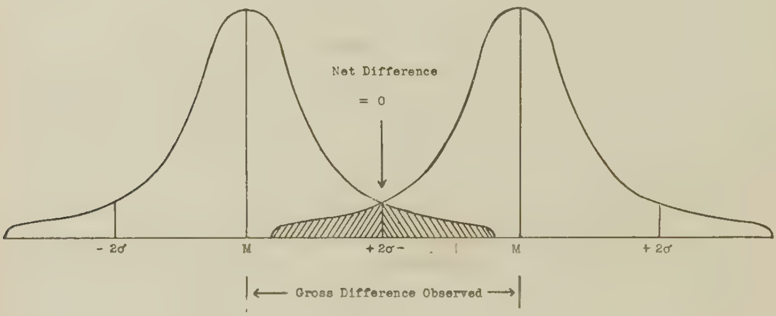



Figure 3.

## The Necessary Difference

Given the variability within a lot, the amount by which one lot must differ from the base or check lot with any degree of reliability decided upon may be calculated from the following formulae:

1. Standard deviation of a difference ($\sigma_d$) between lots I and II equals the square root of the standard deviation of lot I squared plus the standard deviation of lot II squared........ $\sigma_d = \sqrt{\sigma_1^2 + \sigma_2^2}$
2. Standard error of a mean difference ($\sigma_{md}$) is the standard deviation of the differences ($\sigma_d$) divided by the square root of the number of animals per lot........ $\sigma_{md} = \frac{\sigma_d}{\sqrt{n}}$
3. Necessary difference between two means to just allow for chance is found by multiplying the standard error of the mean difference by the "t" value for the odds wanted........ $\sigma_{md} \times$ "t" value

The "t" value of formula No. 3 will be found in Fisher's table of "t" values (Statistical Methods for Research Workers.)

These "t" values are the ratios between means and their standard errors. A "t" value of 2.262, where n=9 and P=.05, would indicate, for example, that with ten animals per lot the mean difference between the two lots must be 2.262 times its standard error ($\sigma_{md}$) before it (the difference) can be considered really due to the experimental treatment in

question, taking as our criterion of significance odds of 19 to 1. Put in other words, we may say that were the comparison repeated, we should expect in 5% of the cases (or once in twenty repetitions) a difference as great as 2.262 times the standard error of the mean difference of any one comparison, due entirely to factors other than the imposed experimental conditions being studied.

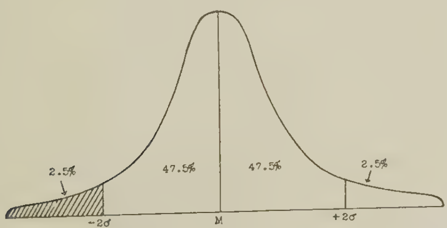
Let us suppose we find a mean difference between two lots of 10 lbs. gain per 100 lbs. feed eaten, and statistical analysis shows us that this 10 lbs. of difference carries a standard error ($\sigma_{md}$) of 2.0 lbs.

From Fisher's table of "t", we find that for n = 10 and P = .05 the $\frac{\text{mean difference}}{\sigma_{md}}$ must be 2.262; or that a difference of anywhere from 5.476 lbs. to 14.524 lbs. ($10 \pm 2 \times 2.262$) might be expected 95 times out of 100. We may also interpret this analysis as indicating that in only 1 case in 40 would we expect from chance alone a difference of less than 5.476 lbs. and likewise in 1 case in 40 a difference of more than 14.524 lbs. On this basis, therefore, we may be sure that there is *at least* 5.476 lbs. of difference between the lots due to the difference in the imposed experimental conditions, and our odds against being wrong are 39 to 1 instead of 19 to 1 because we are measuring in only one direction from the actual mean value of 10 lbs.

But since we have set odds of 19 to 1 as a sufficient margin of safety in this type of problem, we have unduly penalized our interpretation by using the "t" value given for P = .05. In order to find the minimum or least difference which, with odds of 19 to 1, we can safely credit to our experimental treatment, we must use the "t" value given under P = .10 instead of P = .05 for as already explained when measuring only in one direction, which is what we are doing in obtaining a least or minimum difference, the probabilities indicated in the table of "t" values should be doubled.

The "t" value for n = 10, P = .10 is 1.833 instead of 2.262, which gives us a range of from 6.334 to 13.666 ($10 \pm 2 \times 1.833$) between which we expect 90% of our observations to fall, and the odds of getting by chance alone a value less than 6.334 lbs. are 19 to 1.

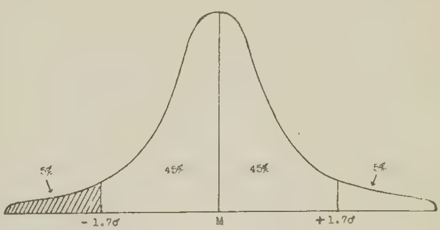
The relation between P = .05 and P = .10 may be illustrated graphically as follows.




Division of normal frequency curve. "t" value = 2.0 for P = .05

(Figures show per cent of observations expected to fall within areas indicated.)

Figure 4.




Division of normal frequency curve. "t" value = 1.7 for P = .10

(Figures show per cent of observations expected to fall within areas indicated.)

Figure 5.

It will be noted that here the "t" values used are 2.0 and 1.7 respectively, while in our example we had values of 2.262 and 1.833 for the 5% and 10% points. This is due to the fact that the graphs are constructed on the basis of large numbers, that is, the normal distribution of variates about their mean, while in dealing with small samples or groups (less than 30) the distribution has been found to differ slightly from the standard curve. Thus, while plus or minus twice the standard error of a mean normally includes 95% of the variates in a large population, it is necessary to increase this margin above and below the mean as the numbers of observations diminish, until with but ten animals per group the standard error of the mean must be increased 2.262 times to include all but 5% of the variates. Thus the "t" value for each value of P will change according to the numbers involved.

The relation between P = .05 and P = .10, however, is accurately indicated in these charts since "n" is the same in each case.

### The Net Difference

The use of the "t" values should be clearly understood in connection with their use in determining the necessary difference and from that the "net difference" between comparative lots.

It should be remembered that the most likely difference is that indicated by the averages found. We know, however, that such averages are not infallable and to be on the safe side we deduct from the average difference the maximum difference which we would expect might occur by chance once in 20 times. The remaining difference, if there be any, is taken as a maximum which can be counted on with "practical certainty" as due to real differences in the rations involved, and not to the pecularities of the experimental subjects or the technique of the trial.

The net difference is not the most probable difference between the two rations tested, but rather the maximum difference which can be proved to be due to differences between the experimental treatments.

### Group Feeding

It is customary to express the results of comparative feeding trials chiefly in terms of three items; Gain in live weight (or production), Feed eaten, and Feed required per 100 lbs. of gain (or its reciprocal, Gain per 100 lbs. feed). Of these items only the first can be obtained in group feeding for each animal of the lot. Hence it is impossible to calculate the standard deviations for the feed consumption or the gain per 100 lbs. feed eaten.

However, an estimate of the average variability within group fed lots in these two items can be made, provided; first, that a reliable average percent variability of gains within lots can be established for the class of stock in question, and secondly that a significant correlation exists between the variability of the live weight gains and the variability of each of the two other items.

### Variability of Gains

On the first of these items (the variability of gains) Mitchell and Grindley (Ill. Bul. 165) in an extensive study of the question report a figure of 17% for hogs and cattle, and 21% for sheep.

Evvard (Iowa Res. Bul. 86) reports coefficients of variability of gains of 14.9%, 18.1% and 13.7% respectively in three trials with hogs; and these are within expectation on the basis of Mitchell's figure of 17%.

In 38 trials with individually fed hogs at Macdonald College, an average variability of 16.9% was obtained. This close agreement with the results in group fed lots, not only strengthens the figure of 17%, but also suggests that the data from individual feeding may be useful in establishing corresponding values applicable to group feeding.

Biologically there is no reason for believing that there should be any less correlation in group than in individual feeding between feed eaten by an animal and the resulting gains in live weight. The factor of competition at the feed trough might in hand feeding be a factor influencing the variability in feed consumption within a lot but this in turn should be reflected in the variation in the resulting gains.

It follows, therefore, that if the variability of the feed consumption within lots individually fed is correlated with the variability of the gains and with the gains per 100 lbs. feed eaten, then an average variability in these two items in group feeding may be estimated from the average variability of the corresponding live weight gains.

Tables 1 and 2 give some of the statistical characteristics of the 38 trials above mentioned.

TABLE 1.—*Per cent variability in live weight gains, feed eaten, and gain per 100 lbs. feed eaten. (Hog feeding trials—individually hand-fed—Macdonald College).*

| Item | No. Trials | Average % Variability | Standard Error |
|---|---|---|---|
| Live Weight Gains | 38 | 16.9 | 1.4 |
| Feed Consumption | 38 | 12.6 | 1.1 |
| Gain per 100 lbs. Feed | 38 | 11.1 | .6 |

TABLE 2.—*Correlations between the variability within lots for gains and (1) feed consumption and (2) gain per 100 lbs. feed eaten. (Hog feeding trials—individually hand-fed—Macdonald College).*

| Variables Correlated | No. Trials | Coefficient of Correlation (r) | Value of r necessary for P = .01 | Regression Coefficient (b) |
|---|---|---|---|---|
| Variability of Gains and variability of Feed Eaten | 38 | .86 | .41 | .67 |
| Variability of Gains and variability of Gain per 100 lbs. Feed eaten | 38 | .61 | .41 | .50 |

Table 3 gives to the nearest .25% the estimated average per cent variability within lots, group fed, of Gains, Feed Eaten, and Gain per 100 lbs. Feed Eaten. The variability in gains of 17% for hogs and cattle and 21% for sheep are those given by Mitchell. The figures for the Feed

Eaten and the Grain-Feed ratio are calculated from the data in Tables 1 and 2 above.

TABLE 3.—*Estimated average per cent variability within lots, group fed, of gains, feed consumption and gain per 100 lbs. feed eaten. (Figures to nearest .25 %).*

| Item | Hogs and Cattle | Sheep |
|---|---|---|
| | $\sigma$ in % | $\sigma$ in % |
| Live weight gains | 17.0 | 21.0 |
| Feed Consumption | 12.5 | 15.5 |
| Gain per 100 lbs. Feed (or Feed per 100 lbs. Gain) | 11.25 | 12.5 |

## NECESSARY DIFFERENCES

From the data in Table 3 the per cent of difference necessary between comparative lots in group feeding trials may be estimated from the formula:

$$\text{Necessary difference} = \frac{\sigma_d}{\sqrt{n}} \times \text{“t” value for odds wanted.}$$

These differences for odds of 19 to 1 have been calculated for numbers of from 10 to 400 inclusive and are presented in Table 4, or may be read directly for any number between 10 to 400 from Charts I and II.

TABLE 4.—*Per cent by which a comparative lot must differ from the base or check lot to allow for uncontrolled variability within the feeding groups, using odds of 19 to 1 as significant.*

| Number animals per group | "t" value | Necessary Difference $= \frac{\sigma_d}{\sqrt{n}} \times$ "t" value | | | | | |
|---|---|---|---|---|---|---|---|
| | | Hogs and Cattle | | | Sheep | | |
| | | Gains | Feed | Gain per 100 lbs. Feed | Gains | Feed | Gain per 100 lbs. Feed |
| n-10 | 1.833 | 13.91 | 10.58 | 9.13 | 17.24 | 12.61 | 10.14 |
| 20 | 1.729 | 9.28 | 7.06 | 6.09 | 11.50 | 8.41 | 6.77 |
| 30 | 1.697 | 7.43 | 5.65 | 4.88 | 9.21 | 6.74 | 5.42 |
| 40 | 1.645 | 6.24 | 4.75 | 4.10 | 7.74 | 5.66 | 4.55 |
| 50 | 1.645 | 5.58 | 4.25 | 3.66 | 6.92 | 5.06 | 4.07 |
| 60 | 1.645 | 5.10 | 3.88 | 3.34 | 6.32 | 4.62 | 3.72 |
| 70 | 1.645 | 4.72 | 3.59 | 3.10 | 5.85 | 4.28 | 3.44 |
| 80 | 1.645 | 4.41 | 3.36 | 2.90 | 5.47 | 4.00 | 3.22 |
| 90 | 1.645 | 4.16 | 3.16 | 2.73 | 5.16 | 3.77 | 3.03 |
| 100 | 1.645 | 3.94 | 3.00 | 2.59 | 4.89 | 3.58 | 2.88 |
| 120 | 1.645 | 3.60 | 2.74 | 2.37 | 4.47 | 3.27 | 2.63 |
| 140 | 1.645 | 3.33 | 2.54 | 2.19 | 4.14 | 3.02 | 2.43 |
| 160 | 1.645 | 3.12 | 2.37 | 2.05 | 3.87 | 2.83 | 2.28 |
| 180 | 1.645 | 2.94 | 2.24 | 1.93 | 3.65 | 2.67 | 2.15 |
| 200 | 1.645 | 2.79 | 2.12 | 1.83 | 3.46 | 2.53 | 2.04 |
| 240 | 1.645 | 2.54 | 1.94 | 1.67 | 3.16 | 2.31 | 1.86 |
| 280 | 1.645 | 2.36 | 1.79 | 1.55 | 2.92 | 2.14 | 1.72 |
| 320 | 1.645 | 2.20 | 1.68 | 1.45 | 2.74 | 2.00 | 1.61 |
| 360 | 1.645 | 2.08 | 1.63 | 1.37 | 2.58 | 1.89 | 1.52 |
| 400 | 1.645 | 1.97 | 1.50 | 1.30 | 2.45 | 1.79 | 1.44 |

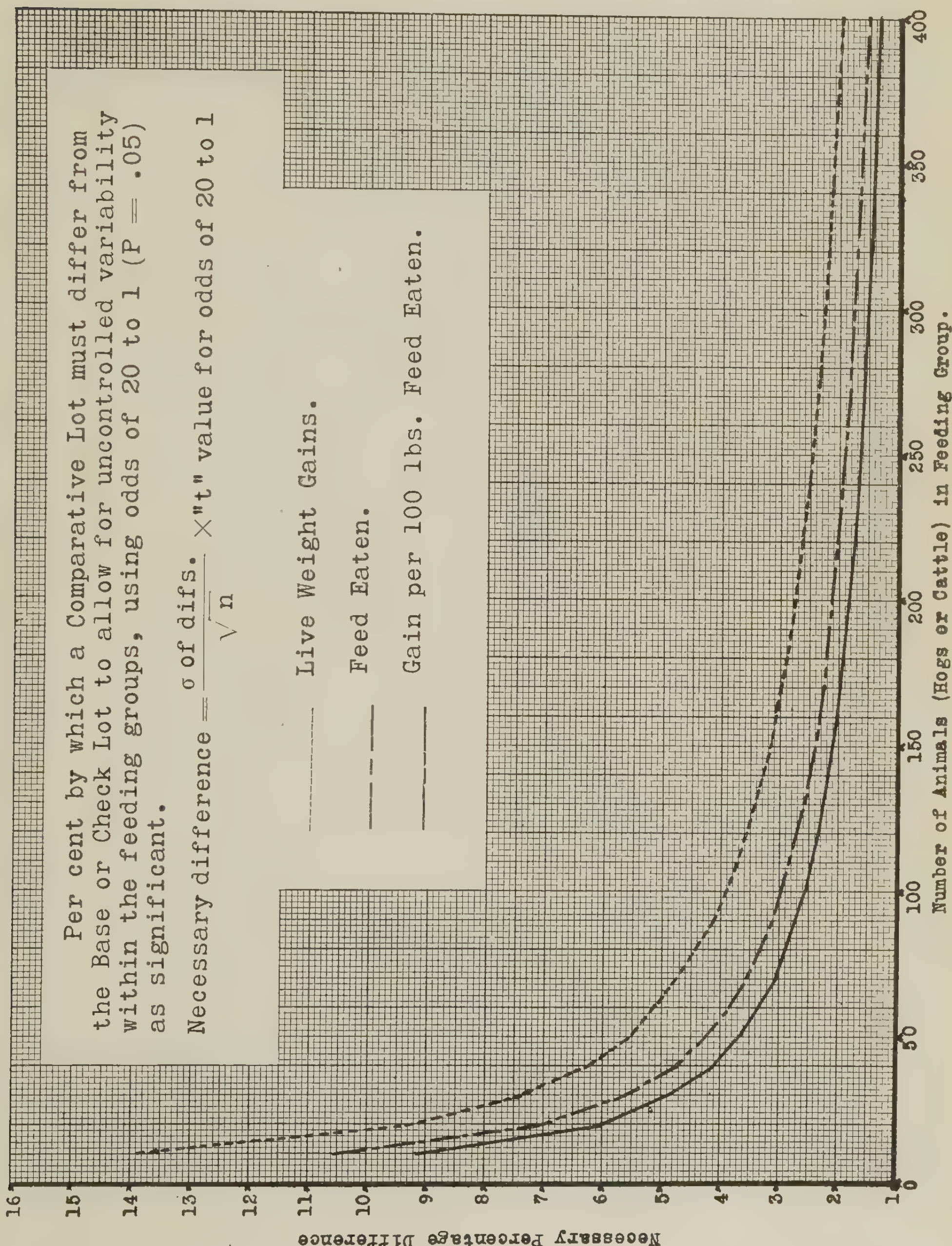

Per cent by which a Comparative Lot must differ from the Base or Check Lot to allow for uncontrolled variability within the feeding groups, using odds of 20 to 1 (P = .05) as significant.
Necessary difference = $\frac{\sigma \text{ of difs.}}{\sqrt{n}} \times$ "t" value for odds of 20 to 1
Live Weight Gains.
Feed Eaten.
Gain per 100 lbs. Feed Eaten.
Number of Animals (Hogs or Cattle) in Feeding Group.
0
50
100
150
200
250
300
350
400
Necessary Percentage Difference
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Chart I.

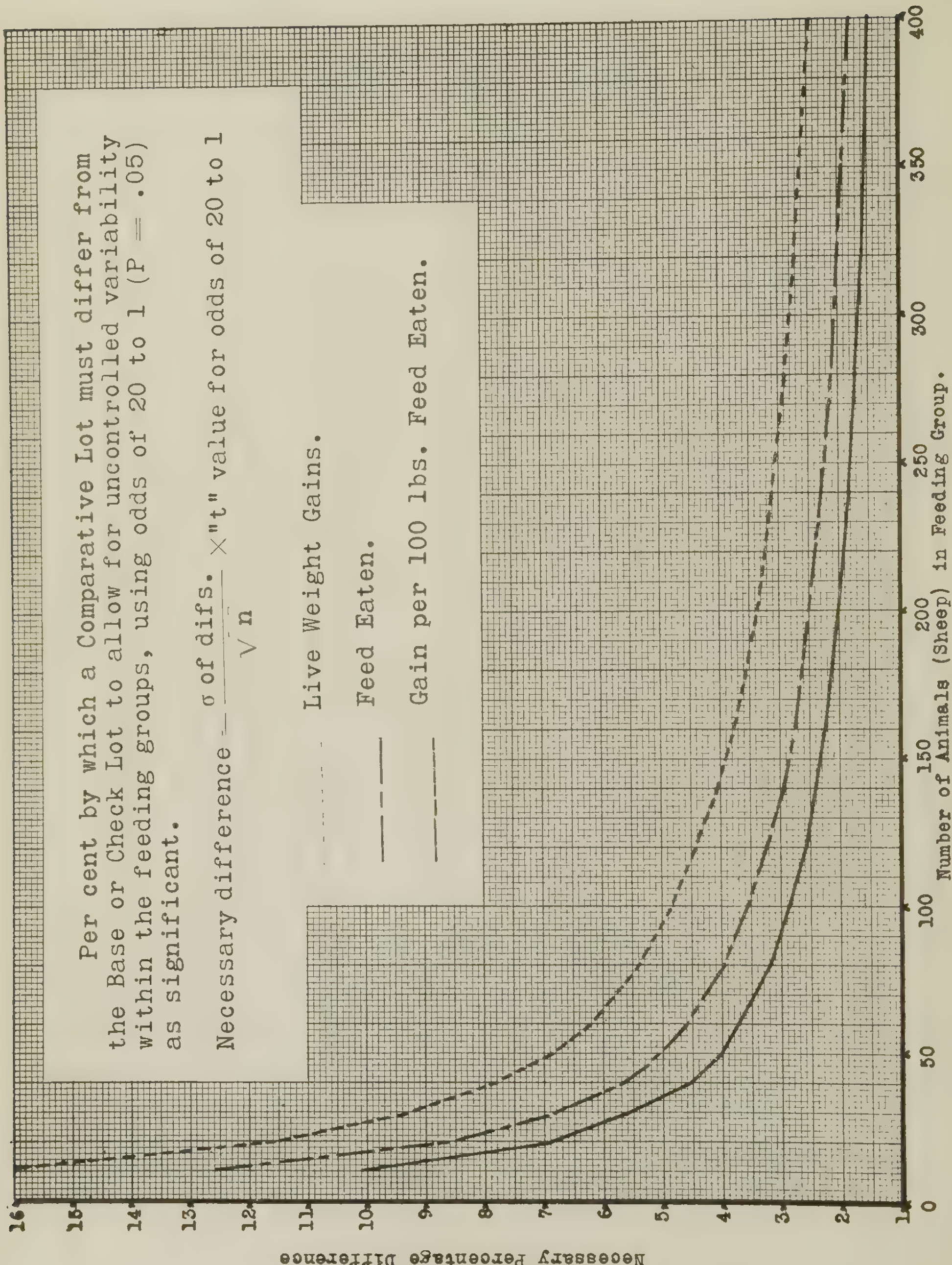

Per cent by which a Comparative Lot must differ from the Base or Check Lot to allow for uncontrolled variability within the feeding groups, using odds of 20 to 1 (P = .05) as significant.
Necessary difference = $\frac{\sigma \text{ of difs.}}{\sqrt{n}} \times$ "t" value for odds of 20 to 1
Live Weight Gains.
Feed Eaten.
Gain per 100 lbs. Feed Eaten.
0
50
100
150
200
250
300
350
400
Number of Animals (Sheep) in Feeding Group.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Necessary Percentage Difference

Chart II.

It should of course be understood that in the calculation of a necessary difference the use of an average variability figure is less desirable than the use of the actual variability existing in the trial being analysed. But in group feeding it is impossible to obtain a measure of the variability of either the feed eaten or the feed-gain ratio. The average variability figures herein suggested for these items are of necessity based on fewer observations than would be ideal, and may be subject to correction as additional data become available. It appears probable, however, that any change will be toward a smaller variability figure, in which case the present calculated necessary differences will be over conservative.

## CURRENT PUBLICATIONS

CONTRIBUTIONS TO CANADIAN ECONOMICS. Volume 4, 1932. University of Toronto. Studies on History and Economics.

This volume contains two articles and a list of Research on Canadian Economics under way and a Bibliography of Publications on Canadian Economics for 1930 and 1931. The first article by Mr. R. H. Fleming entitled, "Phyn, Ellice and Company of Schenectady," traces the history of the North West Company back to one of its main sources. It is particularly important in showing the place of the St. Lawrence in the development of business organization in North America. The second article by Professor C. R. Fay entitled "Canada and Imperial Economic History," gives a review of several aspects of trade development in several of the Dominions.

The list of research projects and the bibliography of Canadian publications are not complete, but are very nearly so. The bibliography includes many popular articles from trade journals and magazines. These latter give a good picture of what the people are being led to think on economic questions and are perhaps more valuable in their historical aspect than as contributions to the science of economics. It is announced that succeeding volumes of this series will be published semi-annually and will include bibliographies for half yearly periods. —H.L.T.

A STORY OF WHEAT. E. Cora Hind. Reprinted from the Canadian Geographical Journal, Volume 2, No. 2, February 1931, and republished through the courtesy of the Winnipeg Grain Exchange.

This reprint, with a foreword by T. J. Harrison, President of the Canadian Seed Growers' Association, was distributed on the occasion of the unveiling of the cairn commemorating the first shipment of wheat from Western Canada to Eastern Canada. The article by Miss Hind is a very excellent account of the development of wheat growing in Western Canada. It is a great story and one well worthy of occupying a premier place in Canadian history. The Canadian Geographical Journal is to be complimented on the fine manner in which the article was printed. The illustrations are numerous and excellent. A limited number of copies are available from the Canadian Seed Growers' Association, Ottawa. —H.L.T.

# COMMENTS ON DEPRECIATION AND REPAIRS OF COMBINE HARVESTERS AND TRACTORS ON THE CANADIAN PRAIRIES

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In the compiling of farm business survey data, and in related studies of the costs of operating farm implements, it is always a problem to know what rate of depreciation should be used on the various classes of farm implements.

To calculate the rate of depreciation on the more costly machines, such as tractors and combines which have a comparatively short life, presents a much more serious problem than for the other general farm machinery. In this article an attempt is made to develop a satisfactory method for the calculation of depreciation on combines and tractors in Western Canada under the average conditions which prevail where these machines are operated.

Depreciation in value is due to two factors, (a) obsolescence,[2] and (b) wearing out of the machine by actual use. The importance of each of these factors must be satisfactorily appraised in order to give each factor its proper weight.

If a method for the calculation of depreciation is to be considered satisfactory for expensive and complicated machinery, it should meet the following tests; (1) The present value, as calculated, should have some relationship with the trade in value of the machine; (2) The depreciation charge of any one year, should be related to the work done by the machine during the year, as nearly as possible; (3) the charges for depreciation per unit of work done during the first years, compared with the charges per unit during the last years, should be such that when consideration is given to all cash and non-cash costs per unit, including those resulting from lost time and losses due to the untimeliness of work, the total costs per unit of operation should be approximately equal.

As it has not proved practicable to develop a method for the calculation of depreciation which completely satisfies all three requirements, the objective has been to develop the most accurate method of a practical character.

For the purposes of comparison, some of the more commonly used methods of determining depreciation are mentioned. The "straight line" method is the one most generally used for the calculation of depreciation.[3] By this method the total amount to be depreciated is divided by the number of years of useful life of the machine, the quotient being the amount of the annual charge for depreciation. The charge calculated by this method is the same for each year during the life of the machine, and therefore it will not fulfil any one of the three requirements mentioned.

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[1] Field Assistant, Agricultural Economics Branch, Dominion Department of Agriculture, stationed at University of Saskatchewan, Saskatoon.

[2] Kohler and Morrison, Principles of Accounting, page 175—"Obsolescence is extraordinary depreciation attributable to new inventions, changed operating conditions, and so forth."

[3] McMurray and McNall—"Farm Accounting—Principles and Problems" pages 59 to 64 inclusve.

According to the "unit of product" method, which is somewhat similar to the "straight line" method, depreciation is spread evenly over the estimated number of units of work to be accomplished by the machine during its life. By this method the charge for depreciation is the same for each unit of production which satisfies the second requirement perfectly, but does not satisfy the other tests.

The "sum of the year digits" method is commonly used when the annual depreciation decreases with increase in age. According to this method the difference between the initial cost and the residual or scrap value, which is the amount to be depreciated, is divided by the sum of all the digits representing the years of the asset's estimated life; in order to obtain the charge for any given year, the quotient is multiplied by the estimated number of years the asset is yet to be used, including the year for which the charge is being calculated. This method will give a net worth more nearly equal to the trade in value than any other method, but will not fulfil the second requirement, as the charge for depreciation will not be related in any way to units of production. Considering the third stipulation, it is doubtful whether the charge calculated by this method would be equitable, as the charge is very low during the latter years of the life of the machine.

The method of calculating depreciation, as developed in this article, is a combination of the methods two and three, since the "sum of the year digits" method is used to calculate the depreciation caused by obsolescence, and the "unit of product" method is used to calculate repairs required and depreciation due to operation. The net worth as calculated by this method is more nearly equal to the real trade in value than the value found by the "sum of the year digits" method, especially in extreme cases of high or low operation per year. The total depreciation charge per year is less closely related to the work done during the year than the charge calculated by the "unit of product" method, but gives a more equitable charge than the "straight line" or "the sum of the year digits" method. The valuation of the different items making up total costs mentioned in the third requirement of a good depreciation rate, depends a great deal on the type of work being done. If during the combining of a heavy crop of high grade grain trouble develops with either a combine or tractor resulting in delay in harvesting when conditions are right for doing this work, the actual cost of the delay may equal the cost of either of the machines involved. For this reason the factor of reliability may be of very great importance. In most cases the unreliability of a machine costs a good deal more in losses of time to men and implements, and losses caused by untimeliness of operation, than many people realize. The "straight line" and "unit of product" methods would make the total costs too high during the latter years, and too low during the earlier years since the only differences in overhead would be in the interest charges. The "sum of the year digits" method will in most cases give too low an overhead charge during the latter years as compared with the former years. It is believed that the method here developed will fulfil this last requirement better than any of the other methods mentioned as it will give a charge during the latter years higher

than the "sum of the year digits" method and lower than the "unit of product" method.

Records of farms on which combines and tractors have been used have been collected in studies made coöperatively by the Farm Management Department of the University of Saskatchewan, the Canadian Pioneer Problems Committee and the Agricultural Economics Branch of the Dominion Department of Agriculture. From these records of Saskatchewan and Alberta farms, data on 126 combines in five different areas and on 437 tractors in seven different areas were made use of in developing a rate of depreciation.

### Combine Depreciation

If the combine were not used at all, but allowed to stand out with the negligible amount of shelter commonly supplied in Western Canada, it can be reasonably estimated that after 20 years it would have value merely as scrap. It would be quite out of date, parts would be difficult to obtain, it could not be operated as easily or as efficiently as the new up-to-date models; thus the only part likely to have any significant value would be the motor which could be used as a stationary engine, the net value of which might possibly be $50. This decrease in value would be depreciation solely due to obsolescence. It is estimated in these studies that any combine, after having harvested a good many acres and having no more practical value as a harvesting machine, would also have this scrap value of $50.

Machines which are brought nearer to perfection from year to year by new inventions and new designs, thus improving handling and reliability, the quality of the work done, and the efficiency of operation, do not depreciate annually at the same percentage of the initial value. In recognition of this important fact, the method used for the calculation of depreciation per year due to obsolescence was the "sum of the year digits" method, which gives a decreasing rate of depreciation with increase in age.

The following example illustrates the "sum of the year digits" method for the combine with a 20 year limit. The sum of the digits from 1 to 20 equals 210. The depreciation due to obsolescence during the first year of ownership would be $\frac{20}{210}$ of the amount to be depreciated, or $\frac{20}{210}$ of the initial value less scrap value; for the second year it would be $\frac{19}{210}$; for the third year $\frac{18}{210}$; and so on.

From data on the 126 combines it was found that on the average each combine had harvested 1371 acres at the date reported, at an average age of 1.94 years. The value of these combines when the farms were visited, based on estimates made by the owners, was 67% of the initial cost, or, in other words, they had depreciated in value 33%, or one-third of their value when new. Should they continue to depreciate at this rate per acre, or per year, the total acres harvested (during their life) would be 4113 acres per combine. However, it is reasonable to expect that with proper care and repairing they will harvest approximately 5000 acres, although it is the opinion of the writer that some of these

combines will not harvest 5000 acres before they are disposed of at practically scrap value, whereas others will harvest considerably more than 5000 acres before reaching the scrap stage.

On the basis of data collected to date and personal observation it is estimated by the Farm Management Department and the Agricultural Engineering Department of the University of Saskatchewan that combines operated by the average operator under average western conditions will harvest approximately 5000 acres. The combines for which data are available have harvested on the average 705 acres per year. It would therefore take about 7 years to harvest these 5000 acres at the rate of 705 acres annually.

The average initial cost of a 15 or 16 foot combine was assumed to be $2250. Some "makes" cost more than this and some less, but this is about the average price paid for the combines studied. Deducting $50 for scrap value leaves $2200 or 97.8% of the initial cost to be depreciated. As the average combine harvests 5000 acres in 7 years, the depreciation due to obsolescence for the 7 year period is subtracted from the total amount to be depreciated to obtain the reduction in value due to the acres actually harvested.

Depreciation due to obsolescence in 7 years[4] equals $\frac{119}{210} \times \$2200 =$ $1247. The balance of the total $2200 to be depreciated, that is $2200 minus the $1247 loss of value due to obsolescence, or $953, is the loss in value due to the acres actually harvested. Since it has been estimated that 5000 acres may be harvested during the life of a combine the charge per acre will be $\frac{\$953}{5000}$ or $0.19. If a combine harvests less than the estimated 5000 acres in the 7 years the obsolence factor in subsequent years, will decrease the total amount allowed for depreciation due to operation, and thus the combine will harvest fewer acres before it will reach the scrap stage.

## Combine Repairs

As the combine harvests crop after crop it is found necessary to replace parts which wear out or break. Since each acre harvested helps in making it necessary to replace the worn or broken parts the cost of these replacements should be charged uniformly for each acre harvested by the machine. From the data available, it is estimated that for each year of 705 acres harvested the average combine will require $40 per year for general repairs and breakages. In addition $110 will be required at some period during the life of the combine for the replacement of chains and sprockets. The total repairs for the 5000 acres would be made up of the general repairs for 6 years amounting to $240, plus $110 for chains and sprockets, making a total[5] of $350. The repair charges per acre for this machine would be $350 divided by 5000 acres which equals $0.07 per acre.

4The figure 119 equals the sum of the digits, 20, 19, 18, 17, 16, 15, 14; which digits represent the first 7 years of life of a combine having a life limit of 20 years.

5Only 6 years were used in calculating the total general repairs, as all breakages occuring during the first year are taken care of by the manufacturer of the machine; worn parts after the first season which in the estimation of the owners will not give complete satisfaction during the second season are generally replaced at the expense of the owner; thus starting with the second year the owner pays for breakages for each year and replaces partially worn parts at beginning of each season, or for a total of 6 years.

If during any particular year the combine is not repaired to the extent of 7 cents per acre it is assumed that the various parts of the machine have been worn, and the value of the machine lessened to the extent of the lack of repairs, as these parts will have to be replaced at a later date. For these reasons the above estimated charge for repairs is included as an important item in determining the total depreciation, and the cost of any repairs placed on the machine during the year is subtracted from the total depreciation to arrive at the actual or net depreciation charge for the year.

The following method has been used in calculating the charge for depreciation for any one year; To the percentage of the initial value which is depreciation due to obsolescence for that year, are added 7 cents per acre harvested for repairs and 19 cents per acre harvested for losses in value due to operation, or a total of 26 cents per acre harvested during the year, and from this total is subtracted the total cost of repairs placed on the combine during that year.

For example:—A combine, with an initial cost of \$2250 when new, harvested 800 acres of crop during the second year of its life. The total repairs for the year cost \$35. The total net depreciation would be $\frac{19}{210} \times (\$2250—\$50) + (800 \times \$0.26) — \$35 = \$199 + \$208 — \$35 = \$372.$

TABLE 1.—*Depreciation per year due to obsolescence, for combines and tractors, expressed in a percentage of the initial cost for the years 1 to 20.*

| Year | Per cent of initial cost | | Year | Per cent of initial cost | |
|---|---|---|---|---|---|
| | Combine | Tractor | | Combine | Tractor |
| 1 | 9.31 | 9.17 | 13 | 3.72 | 3.67 |
| 2 | 8.85 | 8.71 | 14 | 3.26 | 3.21 |
| 3 | 8.38 | 8.25 | 15 | 2.79 | 2.75 |
| 4 | 7.92 | 7.80 | 16 | 2.33 | 2.29 |
| 5 | 7.45 | 7.34 | 17 | 1.86 | 1.83 |
| 6 | 6.98 | 6.88 | 18 | 1.40 | 1.38 |
| 7 | 6.52 | 6.42 | 19 | .93 | .92 |
| 8 | 6.05 | 5.96 | 20 | .47 | .46 |
| 9 | 5.59 | 5.50 | | | |
| 10 | 5.12 | 5.04 | Total....... | 97.78 | 96.30 |
| 11 | 4.66 | 4.59 | Scrap value.. | 2.22 | 3.70 |
| 12 | 4.19 | 4.13 | | | |
| | | | Total....... | 100.00 | 100.00 |

Table 1 presents the depreciation due to obsolescence per year for both combines and tractors for each year, 1 to 20, expressed as a per centage of initial cost when new. This table may be used advantageously when calculating depreciation on a large number of combines and tractors.

Data in Table 1 may be used to facilitate the calculation of depreciation due to obsolescence for each year. The depreciation due to operation, (19 cents per acre), plus the charges for the estimated repairs required, (7 cents per acre), cannot be shown as a percentage of the initial cost of combines. The smaller combine would harvest proportionately less acres in its lifetime than the larger combine, and therefore this depreciation due to wear would be a larger percentage of the initial cost of the smaller combine, but the charge in cents per acre would be approximately

the same for all sizes of combines. The range of acres harvested by combines in Western Canada is very great, as is shown by the data on the 126 combines previously mentioned. For nine of these combines the area harvested was 350 acres or less per year; for 105 combines, from 351 to 1050 acres, and for the remaining 13, over 1050 acres. The extreme range of acres harvested for these combines is from 250 acres to 2000 acres per year.

TABLE 2.—*Acres harvested per year; total life of $2250 combine harvester in years and in acres; and average depreciation plus repairs per acre and per year.*

| Acres harvested per year | Combine completely depreciated in: | | Average depreciation plus repairs during life of combine: | |
|---|---|---|---|---|
| | Years | Acres | Per acre | Per year |
| 100 | 13.5 | 1350 | $1.70 | $170 |
| 200 | 11.4 | 2280 | 1.03 | 206 |
| 300 | 10.0 | 3011 | .80 | 240 |
| 400 | 9.0 | 3610 | .68 | 272 |
| 500 | 8.3 | 4129 | .60 | 300 |
| 600 | 7.6 | 4572 | .55 | 330 |
| 700 | 7.1 | 4957 | .51 | 357 |
| 800 | 6.6 | 5303 | .48 | 384 |
| 900 | 6.2 | 5609 | .46 | 414 |
| 1000 | 5.9 | 5885 | .44 | 440 |
| 1100 | 5.6 | 6137 | .43 | 473 |
| 1200 | 5.3 | 6365 | .42 | 504 |

In the hypothetical cases shown in Table 2 the charge for depreciation and repairs per acre is very high for combines which harvest only a small acreage per year. This is due entirely to the depreciation caused by obsolescence which remains the same in any one year regardless of the number of acres the combine harvests. The saving in depreciation per acre by harvesting more than 700 acres is not very great, and in most districts it may not be advisable to plan on harvesting much more than 700 acres per year with a 15 or 16 foot combine. Where climatic conditions are particularly favorable for combining, as much as 1000 acres of harvesting per machine might be safely considered in a year, whereas in other areas, where the weather is less favorable and more serious risks are involved it may be necessary to plan on harvesting less than 700 acres per year, in spite of the higher charge per acre for depreciation.

## TRACTOR DEPRECIATION

The following information was obtained from the data collected on the 437 tractors previously mentioned. The average age of these tractors was 3.16 years, the average of the farmers' estimates of present values was 56.5% of the average initial cost, and the average hours of use during the year of the study was 417 hours. If it be assumed that on the average these tractors were operated 417 hours during each of the years of ownership, they have been operated to date a total of 1318 hours per tractor. The valuation the farmer has placed on his tractor is largely based on the trade in value set by the implement agent, which is deter-

mined almost entirely by the age of the tractor. These tractors have been depreciated 43.5% of their initial cost at 3.16 years of age, after having run 1318 hours. This is obviously a very heavy rate of depreciation per hour or per year.

The Agricultural Engineering Department of the University of Saskatchewan have been in close contact with tractor operators for many years and have submitted the following data. In their opinion the average farm tractor, which has been sold during the past 6 to 8 years, under the average farm conditions will furnish economical power for approximately 6000 hours. With exceptionally good care some of these tractors will operate satisfactorily for 8000 hours or more, but on the average 6000 hours is considered a reasonable estimate. One 15-27 tractor of which they have a complete history was operated for nine years before being sold for $60 during which time it ran 5900 hours and required $575 worth of repairs.

Even if the tractor were not used at all, it would, like the combine, be completely obsolete in 20 years, and have a value equal only to that of scrap. Some models of tractors which are only 12 years old at the present time, and which have been used very little if at all, have no more than scrap value today. Improvements may not be as rapid in the future as they have been in the past, but the possibilities are great and may even exceed our expectations.

The tractor is also similar to the combine in that it does not depreciate annually at the same percentage of the initial value. In recognition of this fact the "sum of the year digits" method which gives a decreasing rate with increase in age, was used to calculate depreciation per year due to obsolescence.

The majority of tractor owners do not operate their tractors a sufficient number of hours per year to obtain a total of 6000 hours during the life of the tractor. Of the 437 tractors previously mentioned, 240 or nearly 55% were operated less than 400 hours during the year of study, 162 were operated 400 to 799 hours, 32 from 800 to 1199 hours and 3 from 1200 to 1299 hours. Many of these tractors were found on farms which did not provide for more than 400 or 500 hours of tractor work per year even if the available work horses were not used. It is estimated that to obtain a total of 6000 hours of operation from a tractor it should be run 600 hours per year, and have a life of 10 years.

The scrap value of the tractor was assumed to be $50, as in most cases this amount will be allowed by the dealer for an old tractor when purchasing a new one. The initial value of the average tractor of the 15-30 or equivalent size was placed at $1350. Deducting $50 for scrap value leaves $1300 to be depreciated which is 96.3 per cent of the intial cost. As the farm tractor should run 6000 hours in its assumed life of 10 years, the depreciation due to obsolescence for 10 years is subtracted from the total amount which will be depreciated, to obtain the amount to be depreciated by the hours actually operated.

The tractor depreciation due to obsolescence in 10 years, equals $\frac{155}{210} \times \$1300 = \$960$ or $\frac{155}{210} \times 96.3\% = 71.08\%$ of the initial cost.

The balance of the $1300 to be depreciated, (which is $1300 minus the $960 loss in value due to obsolescence, or $340), will be depreciated by the hours actually operated. Since the average tractor will operate satisfactorily for 6000 hours, depreciation per hour due to operation alone is $\frac{\$340}{6000}$ equals $0.057, or 0.042% of the intial cost. If a tractor is not run the 6000 hours in 10 years as estimated, the obsolescence factor will decrease the total amount allowed for depreciation due to operation, and thus the total hours which the tractor will run before it reaches scrap value will be correspondingly less.

## Tractor Repairs

As the tractor pulls its load hour after hour it is gradually wearing all moving parts, and shortening the life of others. Almost every season it is found necessary to replace some part or parts of a tractor. When the tractor is new few parts are usually required per hundred hours of running, but as it becomes older more parts are required and occasionally new cylinder sleeves, pistons and rings are necessary to maintain economical power. The cost of these parts should be charged uniformly to each hour of tractor operation since each hour of running has a part in making necessary the eventual replacement of the various parts. From the data available, and from estimates made by the implement companies and the Agricultural Engineering Department, it is estimated that $600 will be required for repairs for the total of 6000 hours of operation. On this basis the charge for repairs is 10 cents per hour of operation, or 0.0074% of the initial cost of the tractor. If, on the average, repairs equivalent to 0.0074% of the intial cost per hour of operation are not put on the tractor in any particular year, it is assumed that the various parts have been worn and the value of the tractor lessened to the extent of lack of repairs. It is considered that these worn parts will have to be replaced at a later date, and that during the life of the tractor such replacements will amount to 0.0074% of its initial cost for each hour of tractor operation. For these reasons the charge for repairs is considered to be a part of the total depreciation, and the cost of any repairs during the year is subtracted from the total depreciation to arrive at the actual depreciation charges for the year.

The following method has been used in calculating the charge for depreciation for any one year: To the percentage of the intial cost which is depreciation due to obsolescence for that year, are added 0.0074% per hour of use for repairs and 0.0042% per hour for losses in value due to operation. The total depreciation is then expressed in dollars, and from this total is subtracted the repairs for the year, the resulting figure being the actual depreciation for the year.

For example, a tractor with an initial cost of $1350 when new, was operated 650 hours during the third year of its life; the total repairs for the year cost $65.

| | | |
|---|---|---|
| Depreciation due to obsolescence for the year | | 8.25% of the initial cost* |
| Depreciation due to operation per hour | 0.0042% | |
| Repairs per hour | 0.0074% | |
| Depreciation due to operation plus repairs per hour | 0.0116% | |
| Depreciation due to operation plus repairs for 650 hours | (650x0.0016%) | 7.54% of the initial cost |
| Total depreciation plus repairs for the year | | 15.79% of the initial cost |

(1) 15.79 per cent of $1350 = ............... $213
(2) Actual repairs for the year ............... 65

Actual depreciation for the year (1) minus (2) . . $148

*See Table 1.—8.25% is depreciation due to obsolescence for the third year of tractor's life.

TABLE 3.—*Hours operated per year, total life of $1350 tractor in years and in hours of use; and average depreciation plus repairs per hour and per year.*

| Hours operated per year | Tractor completely depreciated in: | | Average depreciation plus repairs during life of tractor: | |
|---|---|---|---|---|
| | Years | Hours | Per hour | Per Year |
| 100 | 15.2 | 1522 | $0.95 | $ 95 |
| 200 | 13.5 | 2695 | 0.58 | 116 |
| 300 | 12.3 | 3689 | 0.45 | 135 |
| 400 | 11.4 | 4542 | 0.39 | 156 |
| 500 | 10.6 | 5306 | 0.35 | 175 |
| 600 | 10.0 | 6000 | 0.32 | 192 |
| 700 | 9.5 | 6624 | 0.30 | 210 |
| 800 | 9.0 | 7193 | 0.28 | 224 |
| 900 | 8.6 | 7714 | 0.27 | 243 |
| 1000 | 8.2 | 8206 | 0.26 | 260 |
| 1100 | 7.9 | 8662 | 0.25 | 275 |
| 1200 | 7.6 | 9085 | 0.24 | 288 |

In Table 3, hypothetical data are used to show that the life of a tractor in terms of hours used is comparatively short if the tractor is only used a few hours each year. Naturally it runs a good many years before it finally reaches the scrap value when used only a little per year, but the charge for depreciation per hour of use is very high as the depreciation due to obsolescence in any particular year is the same regardless of the hours the tractor is operated. The charge for interest on investment is also the same in any particular year regardless of the number of hours the tractor is operated, and therefore the cost per hour of tractor use is very high when the tractor is only used a few hours in a year. A farmer is therefore well advised to consider carefully all aspects of his farm business before purchasing a tractor, to make sure that he has on his farm at least 400 hours of tractor work which can be accomplished more economically with the tractor than with his present source of power.

## EVALUATION OF THIS METHOD OF DEPRECIATION

The allowance of a period of 20 years for a tractor or a combine to depreciate to scrap value through obolescence should not be considered unreasonable in the light of past experience and future expectations. During the past 12 years tractor design and construction have been

improved to such an extent that tractor models of 12 years ago are practically obsolete, and could not be sold to do field work on farms in competition with newer models regardless of price. For the kind of field work now required from tractors these old models consumed more fuel than the modern tractors, per unit of draw bar power produced. They also used more lubricating oil, required more attention by the operators, had more frequent breakages of expensive parts, necessitated a better trained man to run them, and had numerous other disadvantages. Combines have been improved as much, if not more than the tractors during recent years; thus the same conclusions hold with respect to the obsolescence factor in their depreciation.

Although it is not expected that the coming 12 years will see as many new improvements in our tractors and combines as the past 12 years, it is quite reasonable to expect that in 20 years, or by 1952, these machines will be so improved, compared with the 1932 models, that no attempt will be made to sell any unused 1932 models in 1952 except at a figure which will approximate the scrap value as used in these calculations. If in addition, a tractor or a combine is being operated 100 hours per year, it is reasonable to expect that it would take less than 20 years for it to reach the scrap value, and still fewer years to reach this value if it were used twice or three times as many hours per year.

As previously stated, the depreciation rate as developed in this article is based on 20 years for a tractor or a combine to reach scrap value if not used at all. In the case of the combine, 7 years is allowed for it to reach scrap value if 5000 acres are cut in that time, and 10 years to reach this value for a tractor if operated an average of 600 hours per year. Given very good care and attention a tractor or combine might quite easily be operated another year or two at the above rates, but the average tractor or combine only receives average care and attention. Therefore in most cases, at the end of 7 years of harvesting a total of 5000 acres in the case of the combine, and 10 years of 6000 hours in the case of the tractor, it is more economical to trade in the old machine for an up-to-date model. Old tractors and combines which have performed considerable work become less reliable from year to year owing to the fact that many parts have become worn and weakened causing frequent stops through unforeseen breakages. Because these delays may be costly tractors and combines are often traded in before they are completely worn out. These tractors or combines can be used to an advantage where timeliness is not such an important factor.

It is apparent that this combination method of depreciation as developed for combines and tractors, which makes use of the "sum of the year digits" method for depreciation due to obsolescence, and the "unit of product" method for loss in value due to operation, fulfils the three requirements of a satisfactory depreciation rate for expensive and complicated farm machinery more completely than any one of the three methods previously described. It would appear therefore that this method enables the determination of depreciation more equitably than it can be determined by any method previously used in these studies.

# THE ENVIRONMENTAL COINCIDENCE AS A FACTOR IN INCIDENCE AND CONTROL OF PLANT DISEASES.

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The prevalence of disease in agricultural plants and the economic losses ensuing from this source are causes of acute concern to both the farmer and the plant pathologist. The twentieth century has seen a tremendous advance in the diagnosis and control of many pathogenic disorders of plants, but, in spite of the general progress in this science and of the valuable contributions of investigators in individual lines of research, there has been a singular increase in losses from certain types of plant diseases—notably the so-called virus disorders and bacterial and fungus epidemics. Although many of these diseases have been the subjects of observation and experiment both in Europe and America for more than a hundred years, they have continued to defy all efforts in prevention, and still remain a source of controversy and confusion to investigators engaged in studies of diagnosis and control.

A survey of recent investigations and conclusions on viruses, for example, shows remarkably few new discoveries and little disagreement with observations of the previous century. Old records stress the same variability in manifestation and in varietal response to infection, and are a repetition of apparent inconsistencies in incidence, means of transmission, and response to control measures even under specific environmental coincidences. When investigations are carried on and comparisons of behaviour made under totally different environments, conclusions are even more conflicting, and it has become increasingly evident that *only through greater understanding of the basic metabolic disturbances underlying predisposition to such diseases* may any further progress in diagnosis and control be made. The continued failure of investigators to discover effective and economically sound methods of prevention and treatment must be attributed to the difficulty in determining this fundamental cause.

## RELATION OF ARTIFICIAL DISSEMINATION OF PLANTS TO INCIDENCE OF DISEASE

It is significant that during the same period which has witnessed this notable increase in such pathological disturbances, we have also experienced an unprecedented dissemination of plant crops and new varieties to new environments throughout the agricultural world. The rapid advance in the agricultural sciences during this time has been marked by unusual world-wide progress in genetics, and has been accompanied by a corresponding increase in international exchange of agricultural discoveries and developments. These forces, aided by modern facilities for transportation, have resulted in greatly increased distribution of new varieties to foreign countries, and to new environments in the same country.

Modern international competition in agriculture has demonstrated the necessity for maximum yields per acre, and in our zeal to increase yields and quality, we have seized every opportunity to import new plants and varieties which were proving commercially successful in other countries, and have distributed these indiscriminately throughout our own without due regard to the fact that their success may have been restricted to specific environments, and that *potential powers of adaptation to new environments have been undetermined.*

All ecological research points to a definite relation between these two phenomena (geographical distribution and incidence of disease), and the longer the writer studies this problem of increasing occurrence and difficulty of control of certain types of disease in their relationship to problems of plant adaptatiōn, the firmer becomes his conviction that in this indiscriminate dissemination of plants and varieties throughout new environments which demand extreme readjustments of metabolic responses, lies the secret of the enormous increase in occurrence of these disturbances and of our failure to control them. While the type and action of the numerous plant nutrients, as well as cultural methods, may also affect metabolism, these factors are secondary to those fundamental and inherent capacities of a plant which determine its responses to various stimuli.

## Responses of Plants to Changes in Environmental Coincidences

The actual physiological condition of a plant as expressed in terms of health or disease is most difficult to define. While symptoms of some pathological conditions are very characteristic and conclusively establish the presence and identity of specific pathogenes, the expression of other disturbances may be very slight and variable, and causes doubt and controversy as to the actual incidence or identiy of disease. Because of this variability of pathological manifestations under changes in plant variety or in environment, even to the extent of complete recession or masking of characteristic symptoms, it is impossible to draw a definite line between health and disease. For purposes of discussion in relation to practical agriculture, however, we may define *a healthy plant as one which has developed perfect adjustment to the particular coincidence of environmental factors in which it exists.* The degree of adjustment manifests itself in relative freedom from physiological disturbances and in power to resist invasion by pathogenes.

The numerous individual factors which constitute any one environmental coincidence cause daily, seasonal and yearly fluctuations and variations to which plant life in this habitat must develop tolerance. The variations due to length of day occur in rhythmic cycles which are approximately stable in their range of variation from year to year. Those changes in environmental coincidences resulting from fluctuations in temperature and moisture, on the other hand, may occur in much wider range and cause indefinite variability from day to day, season to season, and year to year. In its process of adaptation to its natural habitat, a plant becomes adjusted to the peculiar wide or narrow ranges of fluctuations due to these variable factors throughout this zone. Of all the daily and seasonable variations occurring within this natural habitat, the relation

of length of day to season alone may be regarded as stable, and this approximate uniformity of the light factor from year to year in turn stabilizes the vital processes of the plant so that flowering and fruiting occur under the same range of length of day annually, in spite of seasonal variations in moisture, temperature, etc. This habitat may be termed the survival coincidence of all plants indigenous to this environment, for they have proven their ability to survive, without cultural assistance, under all the variations in combinations of individual factors possible within this zone. Survival indicates complete adjustment to all past fluctuations in interrelationships of these factors, and also a maximum tolerance to all conditions which, by disturbing metabolism, might render it vulnerable to attacks of pathogenes. Under the natural dissemination of plant life the zone of this habitat may or may not be greatly extended, depending upon the inherent ability of the plant to accomplish the necessary adjustments.

When a plant is moved from this natural habitat to which it has developed tolerance it tends to establish similar adjustments in new environments. Immediately a struggle for survival is instituted—*the accumulated tolerance resulting from the composite experience of the plant's struggle for survival, on the one hand, and the changes in response necessary for adjustment to interactive growth factors of the new environment, on the other.* If adaptation is affected and is permanent, it indicates that a state of equilibrium has been reached and is being maintained between these natural forces. But it is important to note that whatever the past experience of the plant, its vital processes, due to the comparative stability of the light factor which controls them, have not developed the same flexibility in response as other processes. This does not mean that all plants are restricted as to length of day under which they will reproduce. Some plants, like barley, whose range of survival habitat is very broad, flower and fruit under great variations of latitude and altitude and corresponding length of day, but those plants whose natural habitat is very limited in length of day variations, are definitely limited as to latitudinal scope of new environment. Their attempts at adaptation to growth coincidences having different lengths of day inevitably result in individual casualties in proportion to the degree of adjustment required for survival. But those plants which do survive under the new coincidence add to their accumulated tolerance additional tolerance to all variations in combinations of environmental factors within the new experience.

*Thus the total inherited tolerance of any plant to environmental changes is merely the consolidation of successful adjujstments to past environments.* The broader this range of experience has been, or in other words, the broader the zones of past habitats and consequently the greater the variability in interrelationships of individual factors, the greater the potentialities for successful adaptations to new environments. All such adjustments impose new responses and habits. Even slight variations in distribution of hours of daylight, temperature or moisture cause different responses from the plant in metabolic, transport and storage habits. Biological history is a repetition of such attempted adjustments, but the gradual change from one coincidence to another, occasioned by the natural

dissemination of plants to new habitats, or by natural re-adjustments or disturbances in combinations of variable factors, do not present the problems in adaptation encountered in the arbitrary distribution of cultivated crops. Under cultivation the differences between the old and new coincidences may be so marked and demand such drastic changes in behaviour that for many species or varieties adjustment is impossible. Failure to achieve adjustment may be due to the fact that some of the new combinations and interrelations of environmental factors may be entirely outside the range of previous experience of the plant, although the range of variability of individual factors may be familiar. For example, a certain variety of oats may have inherited tolerance to the extremes in temperature of one locality, and thrive under excess moisture and long day of a coincidence such as found in northern Scotland; but should the extreme heat, excess moisture and long day occur at the same time as it frequently does in northern Ontario, the extremely rapid growth disorganizes normal metabolism, and invasion by parasites is readily effected.

We find, also, that even under the artificial dissemination of plants in agriculture, adaptations are more easily effected from cool to warm areas, than the reverse. In progressing from cooler to warmer habitats, plants merely recapitulate adjustments to coincidences previously experienced in the natural progression of plant life from tropical to frigid zones. In adaptations to colder habitats and higher altitudes, however, totally new responses must be established.

It must not be concluded that great dissimilarities in growing coincidences are encountered only under extreme variations in latitude, altitude, moisture, etc. In natural habitats where individual factors, especially those controlling vital processes, are fairly stable in their interrelations in respect to individual plants, this may be so; but under cultivation where time of seeding is arbitrary, many totally different growth coincidences in relation to individual plants may be established in a single environment. Early seeding in southern Ontario, for instance, precipitates a growth coincidence which proceeds first with short cool days, cool soil, and abundant moisture. Growth progresses for some time following seeding under an interrelation of lengthening day, increasing temperature of air and soil and variability in moisture depending upon seasonal and regional variations. Maturity of some plants under this coincidence is associated with gradually shortening days and increasing temperatures of July, while others respond only to shorter days with waning temperatures of August. When seeding is later, all growth processes from germination to maturity take place under totally different combinations of these varying factors, and type and rate of metabolic processes are completely changed. It is this increased instability and variability of relationships of environmental factors to plants under cultivation which so complicates the processes of plant distribution and adaptation from an agro-ecological standpoint.

Some plants may have an inherited tolerance for a wide range in temperature but only a narrow range in length of day. Such plants will successfully adjust their growth processes to new environments with widest variations in temperature within the extreme range of their accumulated experience, but within a definitely limited narrow range of fluctuations

in length of day. Other plants have developed tolerance to and will consequently thrive under a wide range of length of day, but will suffer metabolic disturbances under coincidences with other factors outside their accumulated experience. On the other hand, plants such as barley, whose natural habitat covers a very wide and varied zone, have developed tolerance to all fluctuations in coincidences within this zone. Conesquently these plants may be successfully transplanted to a proportionately greater number of new environments.

Although a plant may have developed optimum tolerance to a great range in environmental coincidences, it does not follow that the response in type of growth will be identical under these varying combinations of environmental factors. Changes in the light factor, for instance, will modify the type of growth and the form in which carbohydrates are stored. Increasing length of day during the entire growing season will have a different effect upon growth and storage than the same number of daylight hours divided equally between periods of increasing and decreasing length of day. Varying temperature, moisture, soil and culture in conjunction with different lengths and distribution of daylight, will result in corresponding variations in amount and distribution of growth and storage.

It is probaby this differentiation in types of growth, together with increased storage due to cultivation, increased moisture, and fertilization, which has been responsible for the opinion expressed that the survival coincidence is not always the optium environment for an individual plant. It is not necessarily the optimum for yield but is obviously the optimum for maintenance of health without cultural assistance. *It must also be noted that survival coincidences for individual plants may often be duplicated in other areas than those in which the plant is originally found,* which fact opens up vast possibilities for scientific distribution.

The disturbed metabolism which results from attempted adjustments to unfamiliar environments may find many forms of physiological expression. Where metabolism is only slightly sub-optimum, symptoms may be indistinguishable and tolerance gradually be developed. On the other hand, exposure to specific pathogenes will readily determine the degree of disorder in metabolism of individuals, varieties or strains. Investigation supports the theory that successful invasion under such conditions is in proportion to the accumulated tolerance of the plant to local growth coincidences. The variability in incidence and manifestations of a single pathogene on a given crop under specific environmental and cultural coincidences would preclude any other explanation of predisposition or immunity. Such observations support the value of these conclusions as a working hypothesis for investigations in relation to development of locally resistant strains.

Where derangement of normal processes is more severe it may be accompanied by definite symptoms of physiological disease such as spotting or discolouration of individual organs, or in various types of abnormal functioning and lack of efficiency. Where optimum growth coincidence in relation to an individual plant is disturbed by such factors as extension of growing season after maturity of plant, the metabolic disturbance may

take the form of reversed enzymatic action which reconverts stored carbohydrate into sap. Such physiological diseases as water-core of apple are the result of such action.

The survival coincidence, or that to which the plant has developed optimum tolerance, is obviously most unfavourable for occurrence and spread of disease but will not necessarily produce the most successful plants from a commercial standpoint. This is because the type of growth desired in individual plants will vary according to commercial requirements, and to obtain this growth genetics must be assisted by modifications of minor factors of growth coincidences such as soil, stimulants, and cultural methods. In one plant seed may be valuable, in others root, tuber, leaf, stem or petal. In some cases the commercial value of the various organs of a single crop may vary with the locality. Corn, for instance, is valuable for seed in some coincidences but equally valuable as a silage crop in another locality where the commercial production of seed corn would be unprofitable.

Successful growth from the commercial standpoint then must combine maximum development of specific organs with maximum resistance to disease. Freedom from predisposition to physiological and parasitic diseases in commercially successful crops is governed by the plant's accumulated tolerance to all the modifications in environment necessary to promote desired type of growth as well as to the major factors of environmental coincidence. It would seem that from whichever standpoint we view it the interrelations of a plant's inheritance with specific environments determine its capacity to transform nutrients into desired form, and that *disorganized metabolism may find expression in inefficient functioning of individual organs as well as in susceptibility to invasion of pathogenes.*

On the basis of the foregoing conclusions, one would expect to find a marked relation between geographical distribution of plants in relation to natural habitats and the incidence and physiological manifestations of various types of pathological disorders. Pathological research confirms this opinion for it has become increasingly evident that plants which have suffered the widest geographical distribution in proportion to the limitations of the coincidental tolerance developed in their survival coincidence, are most susceptible to certain types of growth disorders, i.e. the virus and physiological diseases, and various bacterial and fungus epidemics. It is also significant that such diseases are confined chiefly to the commercial varieties of such plants. For example, the potato, which under cultivation shows extreme susceptibility to virus infections, illustrates the necessity for this favourable interrelationship of major environmental factors and individual varieties to insure resistance to these diseases, while yields are increased by modifications of minor factors. In Colorado the world's record potato yields with minimum loss from disease have been obtained under the high altitude, medium length of day, intense light and cool dry air of the survival coincidence of the potato which minimizes susceptibility to disease of either physiological or parasitic origin. Yields, represented in this case by storage in form of tubers, are increased

by breeding, fertilization, cultivation, and increased moisture. As would be expected, moisture increased through sub-irrigation which does not raise the humidity of air and so simulates more closely the conditions of the survival coincidence, is more desirable than additional moisture supplied through surface irrigation or rainfall. In the British Isles the long cool season provides optimum conditions for tuberization. The changes from survival coincidence, however, represented by longer day, lower intensity of light, extreme humidity, and excessive moisture in soil, necessitates metabolic adjustments which render the potato particularly susceptible to disease in these areas. Many strains have through the course of time successfully effected these adjustments and consequently developed optimum tolerance to local conditions. The opinion sometimes expressed, that susceptibility to disease is an unavoidable result of continuous breeding for greater yield, is not supported by observations on potato yields, as the greatest yielding varieties under certain environmental coincidences may be least affected by disease. Intensive cross-breeding of many varieties of obscure origin, and unknown capacities for adjustment to varying coincidences, will obviously complicate disease control, and indiscriminate distribution of these new varieties will further increase not only the incidance but the variability of expressions of diseases on these crops, i.e. the increasing variation in virus manifestations on potatoes, tobacco, sugar-beet, etc. and the increase in physiological forms of rust on wheat.

## Fundamental Nature of Disturbances Underlying Virus Manifestations

A comparative study of disease on farm crops, in view of this relationship between limitations of natural habitat and possibilities for successful agricultural distribution, discloses many significant facts in support of the foregoing conclusions. The potato, which in a comparatively short period of cultivation has suffered singularly wide distribution in proportion to the narrow range of its natural habitat, shows extreme susceptibility to virus diseases. Tobacco, sugar-cane, sugar-beet and cotton show the same tendency. Many older crops, whose natural habitats are clouded by antiquity but whose distribution was necessarily gradual owing to difficulties of communication and transportation, seemed to have developed immunity, or at least tolerance to such diseases, although the newer varieties and strains of the same plants developed under specific environments by the cross-breeding of many strains of different origin and accumulated tolerance, and distributed indiscriminately, are showing extreme susceptibility to various types of infection.

As noted above, the presence of degenerative and virus diseases on farm crops and the failure to discover effective methods of control, constitute one of the major problems in modern phytopathology. In spite of extensive research to determine means of transmission, significance of symptoms, physiological and economic effects, and sound principles of control, little real progress has been made during the last hundred years due to the confusing and contradictory nature of observations and conclusions of investigators.

A survey of recent work on mosaics and other degenerative disorders, however, discloses many significant findings which in spite of conflicting interpretation of symptoms and responses, by individual pathologists, nevertheless present most convincing arguments as to the fundamental nature of the disturbances predisposing to such epidemics. A review of such findings considered in relation to each other is most enlightening, and supports the theory that the apparently contradictory evidence which has led to so much controversy is due to diversities in individual interpretation of observations, rather than to inconsistancies in manifestations of infections or in responses to modifying factors.

While it is not our purpose in this paper to consider that controversial phase of the problem—the specific pathogenes which are the primary cause of virus infection—it is necessary to note the diversities in opinion expressed by pathologists on all aspects of this complex problem and to recognize the true significance of these seeming inconsistencies.

## Nature of Pathogenic Agent and Significance of Variability in Incidence

Contrary to the opinions held by many investigators that the numerous virus diseases of the potato are caused by as many distinct infections, we have the belief expressed by Beauvere (*4*) (France) that all growth disorders of potatoes are manifestations of a single virus. The unanimous evidence of pathologists as to the difficulty of diagnosis of the various degenerative diseases, due to the variability and instability of symptoms, would seem to support this theory. Spindle tuber and unmottled curly dwarf, for instance, may present clearly distinguishable effects upon apparently healthy plants in a specific environment, but under changes in environment the expression of these two diseases becomes indistinguishable (Goss, Nebraska) (*11*). In Prince Edward Island, crinkle and mosaic have never been found together on potatoes, although in other environments these two expressions of disturbance may be present on the same plant (Gussow) (*13*). Smith (*34*) reports that "when aphids were colonized on potatoes affected with a combination either of leaf roll and streak or leaf roll and mosaic, they transmitted only leaf roll to healthy potatoes, but in the case of the latter combination they infected tobacco with a mottling disease identical with that caused when potato mosaic is transmitted to tobacco." He concludes that the aphids pick up both viruses, the separation of which depends mostly upon the plant. Similar results are as logically interpreted by other experimenters as indicating different expressions of a single virus, for the type of expression of a single virus has been found to vary according to the variety or species of plant affected. Experiments in America have also shown that symptoms caused by inoculations from a single virus on one variety will exhibit distinct characteristics under exposure to different environmental contidions. *Consequently we find specific manifestations of virus infection may be consistently associated only with individual varieties of plant under specific environmental coincidences.*

In Minnesota, for instance, spindle tuber is regarded as the most important manifestation on Early Ohio potatoes and mosaics on Bliss Triumph

(McCall) (*27*). In some sections of New Brunswick spindle tuber is very prevalent on potatoes while in other sections it makes little headway, although in these latter areas other symptoms of virus (mosaics) are present. In England, Salaman (*33*), observing the tendency of Crinkle A to manifest different symptoms on different species, concluded that this virus was a combination of viruses. Quanger et al, (*33*) (Holland), on the other hand, express the belief that such differences in expression are due to the differences in susceptibility and manner of manifestation possessed by individual varieties of plants.

Such evidence of variability in incidence and in symptomatology would lead one to conclude that the confusion in nomenclature may also be due to this cause. Johnson (*20*) (Wisconsin), for instance, concludes that the rugose mosaic virus of Schultz and Folsom is identical with the spot necrosis of his observations. In many cases indeed symptoms are so variable as to have little or no diagnostic value. For some obscure reason these infections seem to possess inherent ability to vary type of manifestation, but there is no stability of association between definite symptoms and individual species or varieties, or specific environments. *Such changes in expression all seem to disregard source of infection, and indicate that type of manifestation is governed by some fundamental interrelationships of plant and environment, rather than by nature of pathogenic agent.*

## Effect of Environmental Coincidences Upon Virus Manifestations

Although all investigators admit the modifying effects of environment upon manifestations of degenerative disorders, there is much controversy as to the true significance of this factor, and in view of the conflicting evidence on this phase of the problem it is inevitable that conclusions should be confusing.

Kendall (*23*) (New Hampshire) expresses the belief that in that State the prevalence of mosaic in the north and leaf roll in the south, is attributable to the difference in temperature between the two sections, mosaic being masked at the high summer temperatures of the South. Constantin (*6*) (France) and many others, find high altitudes and low temperatures least favourable for development of any symptoms of viruses, while in New Brunswick, Gussow (*13*) reports that rugose mosaic tended to be masked at low temperature. Riha and Blattny (*34*) (Czechoslovakia), report experiments which "indicate distinct relation between incidence of viruses and environmental changes, but see no relation between type and condition of soil and occurrence of these disorders". They found healthy seed from low altitude of Holland equally healthy in high altitudes in Czecho-slovakia, but in the plains it displayed marked susceptibility to infection. In this connection they draw attention to the fact that although some investigators have advocated the use of seed from high altitudes as means of decreasing infection, the seed from low altitudes of Holland were equally resistant in highlands of Czecho-slovakia, but were susceptible in lowlands, while healthy seed transferred from high to low areas has been found to vary in susceptibility in two different coincidences of the same altitude and latitude.

Investigators have reported a definite relation between dates of seeding and harvesting potatoes and the economic losses from viruses. Early seeding and harvesting decrease losses considerably in some cases. As noted above, changes in dates of seeding cause complete changes in interrelations of all environmental factors with specific plant, so it is impossible to say that modification of any one factor, such as length of day, or amount or distribution of moisture or temperature, was responsible for additional tolerance. However, in spite of differences in observation and interpretation, it is apparent that there is general agreement as to the necessity of considering all virus manifestations in the light of environmental variations. But the fact that no single environmental factor should be considered except in its interrelation with all other factors, and with individual plants, has not been sufficiently stressed. It is clearly a problem in which pathologists, physiologists, chemists and ecologists must cooperate, and one in which international as well as local collaboration is essential.

## Means of Transmission

There is almost equal diversity in observations and conclusions regarding the means by which these infections are transmitted. Insect carriers which cause extensive infection in one area may be present in another area without causing a corresponding spread of disease. Although most authorities agree that aphids and other insects are the chief agents of transmission, we find that the most severe infestation of insect vectors may fail to transmit disease under certain combinations of environment with individual plant varieties or even individual plants. Inoculations from infected juice or by leaf mutilation which are successful with one variety, are impotent with another in the same environment, but results may be reversed under change in environment. One variety of potato, for instance, may become disastrously infected while another exposed to identical agencies of transmission and surrounded by diseased plants in the same environment, remains unaffected. In all epidemics of viruses, agents of transmission are secondary to the inherent capacity of the individual plant to maintain optimum metabolism under a specific environmental coincidence and thus resist invasion.

## General Conclusions to be Drawn from the Foregoing Evidence

From the masses of such apparently contradictory observations and conflicting conclusions, however, the following evidence may be isolated as to the existence of a fundamental metabolic disturbance underlying and preceding all manifestations of virus infection:

1. That while virus infection may be the immediate cause of degeneration, it is absolutely dependent upon the existence of a specific coincidence of pathogenic agent with other favourable conditions of host and environment, to precipitate successful invasion and to determine type of manifestation of disease.

2. Experiments have proven conclusively that various agencies have power to transmit infection, but that this power is effective only under certain combinations of pathogene, environment, and plant varieties or strains.

3. Environment, although an extremely important modifier of virus manifestation, does not in itself control the occurrence or expression of virus infection, as shown by the variability of incidence within a limited area of specific environmental coincidence. No specific modifications of individual factors in environment such as soil, altitude, latitude or moisture may be consistently associated with incidence of virus diseases, but complete changes in growing coincidences brought about by change in dates of seeding and harvesting, have been shown to have a definite relation to incidence in an individual area. Such changes in occurrence and duration of growing season are, however, usually associated with changes in varieties sown, so that again we are confronted with the futility of considering the pathological effects of environmental or varietal changes except in their interrelations.

4. Individual varieties, strains and even individual plants vary in their response to virus infection under the same environment and also under different environments. Individual environmental factors such as temperature, moisture and altitude, cause varying responses from infected plants, governed by the interrelation of these factors with the others which constitute the environmental coincidence in which the plants exist.

5. No variety or strain or individual when considered without relation to environment may be said to possess immunity or greater resistance to infection than another. A change in environment by disturbing metabolism may render healthy seed a prey to various agencies of transmission, or may activate latent or masked infections.

## Difficulty of Evolving Control Measures Due to Contradictory Conclusions of Investigators

In view of the conflicting opinions based on the above findings regarding causes and manifestations of degenerative diseases, it is not surprising that investigations in methods of control have been singularly unsuccessful. But again in this field many individual observations of fundamental significance have been recorded, and comparisons of many potato-growing areas in America and Europe in respect to incidence and control of viruses have revealed much valuable data.

Although many regions suffering losses from viruses showed successive increase in infection from year to year, in spite of importation of apparently healthy seed, individual regions were found in Holland where disease did not become either more or less severe in successive years. In these areas no new seed was imported, suggesting that the local strain had developed and maintained a certain degree of tolerance to this environment beyond which it could not advance. In Ireland also, investigators have found many sections practically free from the more serious types of degeneration, and in these areas local strains were cultivated, while in those areas near the principal cities using imported seed, infection was excessive. In Sweden, although Magnum Bonum (imported) becomes eliminated in four years, locally developed strains of this variety have remained free from disease for many years in the midst of susceptible and infected varieties. Similarly in Russia, although all virus diseases of potato occur,

infection is chiefly confined to those regions where foreign seed has been introduced. The locally developed strains show much greater resistance to infection under all the unfavourable and contributory conditions which may occur periodically in any environmental coincidence. In Bulgaria also, varieties have been discovered which never show symptoms of virus infection even when grown in proximity to infected stocks. Such plants, however, may really be infected although symptoms remain masked, and may transmit disease to varieties less tolerant to local conditions. It would seem that such plants have themselves developed maximum tolerance to local conditions, and would consequently be valuable as sources of resistant strains for local use. The futility of expecting of such locally resistant strains a permanent quality of resistance which will be effective under various environmental conditions is demonstrated by the failure of resistant local strains of seed potatoes from Holland and Scotland to retain this resistance in many foreign environments. The value of resistant strains is largely dissipated by indiscriminate distribution of seed.

Kotilla and Coons (*24*) (Michigan) observe that in local strains developed from single tubers there is great uniformity of plant type and almost total freedom from viruses. In Pennsylvania, of six native strains which have been under cultivation for many years and exposed to virus infection, two show promise of inherent resistance to degenerative diseases.

### Value of Change of Seed in Controlling Virus Infection

A survey of the history of degenerative diseases of the potato shows that although these disorders as an economic problem date from the period when importation of foreign seed became common, a change of seed has been continually advocated as a means of control. Investigation shows, however, that new seed is not consistently less susceptible than local seed. As early as 1837 Edward Carrol, in "Irish Farmers' and Gardeners' Magazine," June 1837 (Davidson) (*8*), mentioned a specific variety of early potatoes which had been grown in the same garden for fifty years with freedom from disease, although the late varieties in the same garden were infected, and then Mr. Carrol goes on to show that in other areas in Ireland at this time, early varieties were extremely susceptible. Nearly a hundred years later we find the Dutch Fresian Co-operative Sale Association for seed and plant material supplying 200,000 cwt. of healthy seed potatoes to various European countries and Africa, due to the use of locally developed strains, the chief of which (the Old Ergenheimer variety) is over 70 years old. But in following up the history of healthy seed of resistant strains exported from Scotland and Holland, we find that it is not consistently healthy in new environments as shown by reports of Blatny (*32*) above, showing diversity of results in Czecho-slovakia. The fact that many districts continue to import fresh seed from the same source every year shows that these areas have not recognized the fact, long since accepted by successful Dutch growers of seed potatoes, that any variety which does not develop tolerance to local conditions shown by resistance to virus and other diseases in three years' trial, should be discarded in that locality.

As would be expected, efforts to develop resistant strains by continuance of such importations have been notably unsuccessful. In sections of British Columbia stock grown from apparently healthy imported certified seed, showed 100% infection after two years, while the serious degeneration of potatoes in Ontario Regional Coincidence No. 1 (Ottawa Valley) is generally attributed to the importation of seed from Europe.

Thus, while a change of seed may often be beneficial, it frequently introduces or increases infection. Seed from high cold areas shows most resistance to infection, but there is no uniformity in degree or permanence of this resistance. As early as 1813 it was recognized that new seed sometimes showed increased resistance and yield after the first year and sometimes decreased. *There is no virtue in change of seed alone. Healthy stock from specific environments, considered in the light of its accumulated tolerance in relation to new environment, is essential.*

In Louisiana, mosaic on sugar-cane is a source of heavy losses in that crop. Importation of healthy stock from other areas has not solved the problem as it rapidly becomes 100% infected and importation of new stock in great quantities (3 to 5 tons per acre) would be necessary every year, which is an impractical measure. In Java, mosaic-resistant local strains have been developed and are being used as a source of stock for other sugar areas. That such strains will not be equally tolerant to infection in all new environments is evident. The success of such adjustments as in potatoes will depend upon interrelation of old and new environments and specific strains.

### Type of Tolerance Developed by Persistent Cultivation of Resistant Local Strains

In Holland, where as noted above some local strains continue to show immunity after many years, other varieties, while failing to develop complete tolerance to environment, maintain an incomplete adjustment or partial tolerance, indicated by slight growth disturbances which neither increase nor decrease in successive years.

Attempts to control viruses by roguing have not been uniformly successful. Where the struggle in adaptation is not too severe it would be successful in time. This is practically what has happened in the older potato sections of Europe which have developed local strains. But where seed stock has been imported and strains crossed indiscriminately without due regard to source in relation to new environment, adjustement is likely to be too slow to be economically sound.

The results of all efforts to develop strains of potatoes resistant to virus infection support the theory that susceptibility to these diseases is the effect of lack of tolerance of the plant to individual environments. The very common degeneration and running-out of healthy seed stock when imported to new environments, demonstrates the error of attributing the qualities of resistance or immunity to plants or varieties except in relation to environment. Resistance and immunity are retained or developed in the new environment in proportion to the adjustment necessary between the inherited experience of the plants, which limits its powers of adaptability, and the responses demanded by new environment.

*As would be expected, those areas having least degenerative diseases have developed healthy seed stock from local strains, which have through a period of time acquired tolerance to local conditions, and not been weakened by importation of foreign stock.*

The absence of serious losses from growth disorders in some of the older potato sections of Europe does not mean that these environments are least favourable for development of degenerative diseases or that the varieties grown are consistently immune from virus infection. On the contrary, history records periodic failures in the past from such diseases, and the same strains when exposed to new environments often show extreme susceptibility. But in these local areas as in ours, certain varieties and individual plants showed unsual tolerance to local conditions, surviving even the devastating growth coincidences which caused periodic potato famines. Gradually, by elimination of less tolerant strains and individuals, only those possessing maximum resistance or immunity survived. Adequate or even maximum tolerance does not necessarily imply total or permanent immunity. It may only represent a degree of tolerance which causes complete masking of symptoms under a specific environment.

## Fungus and Bacterial Diseases

Much that has been said as to the complexity of factors determining susceptibility and resistance to virus infections applies also to those diseases resulting from fungus and bacterial parasites. As the purpose of the present paper is merely to outline the significance of coincidental studies in relation to epidemiology, it is unnecessary to consider in detail the various types of these diseases. Consequently, rust on wheat (*Puccinia graminis* and *Puccinia glumarum*) and Oat Blade Blight (*Bacillus avenae*) Manns, have been selected as representative of each group and as illustrative of the dependence of successful invasion upon specific coincidences involving host, parasite and environment. In regard to these diseases there is much the same variability and confusion in symptomatology as found in viruses, and the effect of individual environmental and varietal factors upon incidence and control are almost equally controversial. There have been many conflicting observations and opinions among investigators as to the significance of special environmental factors and varietal characteristics of host in occurrence of rust epidemics, but it has gradually become evident that there is no single determining factor in host, parasite or environment, with which incidence may be consistently associated.

A review of rust investigation shows many and varied theories as to the controlling factor in precipitating epidemics. It is evident, however, that given a suitable host, a pathologic condition will not result unless favourable temperature, humidity and daylight are coincident with both exposure to infection and the so-called critical period of growth or sub-optimum metabolism of host.

Favourable temperature, humidity, etc., not only as individual factors but in their interrelations, are recognized by all workers as being essential to successful invasion. Favourable temperature before and after inoculation, for instance, in conjunction with sufficient humidity are necessary

for germination; but with all other conditions optimum for development of disease they will be impotent in precipitating epidemics if one factor such as intensity of light is absent while all the other conditions are favourable. The fact that susceptible varieties show greater susceptibility at some stages of growth than others, other conditions being constant, indicates that at certain periods of growth the metabolic processes are disturbed by attempted responses to stimuli to which the plant has not developed tolerance, such as variations in light or temperature which may accelerate or impede the normal distribution and storage of carbohydrate and render the host susceptible to invasion. Given, then, a favourable host suffering from deranged metabolism which renders it vulnerable, with temperature, humidity and light favourable for germination of spores and development of mycelium, an epidemic of rust will follow introduction of spores by either natural or artificial means. While any one of these contributing factors may apparently be the determining factor under individual conditions, it is evident that successful invasion is dependent upon a specific and coincident correlation of all these factors. *The number and severity of epidemics will be in proportion to the occurrence and duration of these favourable coincidences throughout the growing season*, and the greatest possibilities for reduction in number and severity of epidemics lies in reducing occurrence of this hazardous coincidence, so favourable to development of parasite, and so unfavourable to physiological condition of the host.

While climatic factors in individual areas and transmission of spores are largely uncontrollable, it is obvious that there are vast possibilities of modifying susceptibility of the host. As noted above in relation to viruses, the metabolic disturbances which render a plant susceptible to attack seem to be consistently associated with attempted adjustments to unfamiliar growth coincidences. Such adjustments may be necessitated either by distribution of seed to new localities, cross-breeding of strains of widely different origins and accumulated experience, or by changes in date of seeding in the same environments. It has been found that time of seeding, by modifying rate of growth and distribution of storage in individual coincidences, has a marked influence on occurrence and duration of susceptibility of host to all forms of rust invasion. Similar differences in metabolism and susceptibility are observed between plants grown in greenhouse and field at the same time and in the same locality. Climatic and cultural conditions, appearance of parasite, and occurrence of susceptible periods of host may vary from year to year so that most delicate adjustments are necessary between these inter-acting factors affecting metabolism.

As the qualities of immunity or resistance to specific invasions are largely relative and of local significance, it would seem that in any locality those varieties would be most resistant whose accumulated tolerance reduced the occurrence of this coincidence of susceptibility of plant with the particular combination of climatic factors favourable for parasite. A variety to be immune in any locality must possess complete tolerance to all the variations and fluctuations in individual factors and in combinations of factors which may occur in this specific coincidence from day to day

and from year to year. That immunity from rust infection is relative and modified by many fluctuating factors is evident from the diversities in findings of individual workers in fields of wide geographical distribution.

There is also a definite association between physiological type of rust, specialized host, and geographical distribution of the host. Thus we find that rust infection shows physiological variability of expression on a single strain or variety of wheat under different environments. These differences in environmental coincidence may be the result either of change in locality or in time of seeding in one locality. In view of the enormous increase of wheat varieties, and the extensive cross-breeding involved in improvement of yield and quality, aggravated by world-wide dissemination of these new varieties and strains, it is not surprising that there has been a corresponding increase in physiological expressions of rust infection. The tendency of this parasite to vary expression according to variety and geographical distribution of host, is reflected in the many apparently conflicting findings in widely separated localities. Thus we find Hart (*14*) presenting evidence in support of the theory that those varieties of wheat whose stomates opened later in the morning than others showed greater resistance to rust infection, because in this way the favourable climatic coincidence of temperature and moisture necessary for successful invasion was greatly reduced. Extensive experiments carried on at the Dominion Rust Research Laboratory at Winnipeg (Peterson) (*31*) failed to support this contention. Potenza (*32*) (Italy) on the other hand, reports observations indicating a distinct association between time of opening of stomata in relation to occurrence of full sunlight and occurrence of infection. He, however, includes in the essential coincidence, low temperature at dawn. Such apparent inconsistencies of observations may be attributable to the very different environmental coincidences under which experiments and observations are carried on. The difference in the light factor alone in different latitudes and altitudes, as, for instance, between southern and northern Ontario, would completely change concidences under which growth of host and parasite progressed from germination to maturity, and under the present system of agricultural research would preclude any common ground for comparison of results. J. H. Burton (*5*) (Kenya) reports that varieties of wheat which are immune to stem rust on the plains of Kenya are very susceptible at high elevations. Because of this variability of response of both host and parasite under even slight changes in environmental coincidences, it has been found impossible to make accurate tests of local resistance in greenhouses. Susceptibility on a single strain in the same locality may also differ from year to year depending upon the degree of annual instability of environmental coincidences, due either to modification of individual factors or to change in date of seeding. The significance of date of seeding cannot be too strongly emphasized, for it largely determines the entire sequence of environmental coincidences under which an individual plant completes its growth processes. It modifies not only the rate of growth, but type of growth at every stage from germination to maturity. The prevalence of rust on those fields of a single variety planted late, while earlier plantings in adjacent fields show resistance, may be due to disturbed metabolism caused by attempted adjustment to

unfamiliar combinations of climatic factors conducive to greater speed in growth and changed habits of carbohydrate storage, which render the enzymatic action host susceptible to invasion by any pathogene; or to the fact that susceptibility of host did not occur at a time which was also favourable for development of parasite.

In view of this association of rust epidemics on wheat with specific coincidences involving host, environment and pathogene, and of the dependence of all investigations concerning incidence and control on a knowledge of these individual coincidences, it is essential that all environmental coincidences under which wheat is grown in this country and under which investigations are conducted should be accurately defined.

The Oat Blade Blight (*Bacillus avenae*) is another pathological condition which illustrates the definite association between individual plant varieties, environmental coincidences and incidence of disease. For example, varieties of oats which posses maximum susceptibility to this infection when grown in northern Ontario, exhibit almost total immunity in southern Ontario. It is significant that the varieties showing greatest susceptibility in northern Ontario are those of superior quality and yield which were developed in southern Ontario, and possessed many desirable qualities in conjunction with immunity from this parasite when grown under the favourable coincidence of its origin. This variation in response is due to the great difference between the environmental coincidence under which this crop is grown in these two localities, and to the fact that oat varieties which were most successful in yield and quality in southern Ontario were introduced indiscriminately into northern Ontario, regardless of the fact that these strains had been developed under a specific coincidence in southern Ontario, and that desirable characteristics were the results of response to this specific environment.

The climatic and soil conditions of northern Ontario postpone seeding until late in season, so that from the first growth is very rapid and in seasons of unusual rainfall is extremely lush. In many areas of poor drainage, conditions are aggravated by greater delay in seeding and a corresponding speed of growth accompanied by great humidity. As indicated above, this growing coincidence of short season, long day, high temperature and excessive moisture is absolutely foreign to accumulated experience of these varieties and metabolic disturbances result. The later the date of seeding, coupled with extremes in moisture, temperature and poor drainage, the greater the susceptibility to parasitic attack. Those areas which because of topography suffer from poor drainage and delayed seeding, usually reach the peak of susceptibility about July 1st when long days, high temperatures and excessive humidity combine to accelerate growth to a degree foreign to the natural responses of these varieties. The same conditions which disturb metabolism of the plant are most favourable for development of pathogene and create the coincidence essential for epidemics. Although the rapid lush growth of poorly-drained land or coincidences of excessive rainfall render most varieties susceptible to invasion, there is considerable variation in susceptibility due to different origins and accumulated tolerance of oat varieties. But even with these more resistant strains, date of seeding has a marked effect in controlling

susceptibility, and in well-drained localities of northern Ontario certain varieties tolerant to a short period of rapid growth and early maturity possess immunity.

## Discussion

The practical agriculturist, however, may well ask—what is the economic significance of this relationship between physiological condition of host, specific environmental coincidence, and the incidence and control of disease on plant crops; how may the results of such fundamental ecological investigations be made applicable to individual and national problems of crop distribution and varietal selection; what is the outlook for increasing prevention and control of physiological and pathological disorders on cultivated crops through such basic investigations?

Our greatest difficulty in accomplishing the necessary correlation of research lies in the very nature of these studies, which demands concentration of individual workers upon specific and isolated problems, although the ultimate application of findings to economic problems is dependent upon fullest co-operation of the many investigators working in these individual fields. In view of the instability and complexity of interrelationships of host, environment and pathogenes, it is necessary that all results be considered in relation to individual hosts grown under specific environmental coincidences; for it is evident that results of even the most extensive investigations are universally applicable only in so far as the exact local coincidence affecting host, pathogene and environment may be duplicated in other agricultural areas. The basis for wider than local application must be a system of ecological research of international scope, which will facilitate collaboration of agronomists, chemists, physicists, geneticists, mycologists, meteorologists and phytopathologists throughout the entire world. In view of the international roots of the agricultural industry and the increasing practice of international exchange of crops and varieties, it is essential that ecological studies have this fundamental basis. The most accurate and extensive observations and conclusions as to incidence and control of any disease on an individual variety grown under specific environmental coincidence are applicable only to local problems until there have been equally accurate investigations to determine the exact environmental coincidence controlling growth in other localities in which these plants are being grown or may be distributed. This is evident from the great variability in results of investigators working under different coincidences, even such slight differences as those between greenhouse and field in the same locality. By overlooking this need for a common ground on which to base comparisons of findings, much repetition in experiment is necessary to determine responses of plants to prevention and control measures under varying coincidences, and the economic losses are proportionate. Correlation of investigations and elimination of repetition may be effected only when there is an accurate knowledge of the characteristics and geographical limitations of all such environmental coincidences. While either viruses, bacteria or fungi, may be the immediate pathogenes, successful invasion by any of these is dependent upon a specific coincidence of peculiar growth responses of the host, together with environmental conditions favourable for development and dissemina-

tion of the pathogene. Consequently it is essential that all investigations to determine resistance be carried on under the conditions in which the plant will eventually be grown. Susceptibility and resistance being relative and controlled by specific coincidences of heredity and environment, any variations in these coincidences in individual centres of observation render invalid conclusions based on a comparison of findings in such experiments. The fact that two varieties or strains planted on the same date, and subject to the same environmental stimuli show very dissimilar susceptibility on the same dates throughout the growing season, shows that environmental coincidence which will disturb metabolism in one variety is within the scope of accumulated tolerance of the other.

The phenomenal progress which has been made in this country in breeding for yield and quality has not been accompanied by equal success in breeding for immunity from infection. But in view of the complexity in origin and subsequent crosses in these varieties and strains, and the universal distribution throughout different environmental coincidences, it is not surprising that individual and varietal responses to infection shows great variability. There is equal variability in physiological and morphological expressions of such infections, and in viruses, fungus and bacterial epidemics, this variability of manifestation under different coincidences of host, environment and pathogene is in proportion to complexity of inheritance of host and parasite in relation to geographical distribution.

To minimize the drastic adjustments which are so disturbing to optimum metabolic processes of individual plants: (1) it is essential that geneticists should take cognizance of the source, history and environmental responses of all varieties crossed in the breeding of new varieties so that potentialities for successful adaptation to specific environments may be anticipated; (2) no new varieties, however superior in yield or quality, should be released for general distribution until their tolerance to infections under specific coincidences has been accurately determined.

All varieties or strains showing resistance or immunity should be labelled with source of varieties crossed and be accompanied by accurate definition of growing coincidence under which these negative responses to specific infections have been achieved.

It would seem that by limiting the strains and varieties in a given region to those showing potentialities of local resistance to specific infections, and by preventing weakening of these strains by continual and indiscriminate crossing with those of undetermined tolerance, a most important step in solving this problem will have been taken.

## Fundamental Principles Affecting Incidence and Control of Plant Disease

The variability in incidence of disease, and in manifestations of specific pathogenes on a single crop under specific cultural and environmental conditions, indicates the presence of some predisposing factor which is not consistently associated with either specific plant varieties, pathogenes or environmental coincidences.

Ecological investigations point to the deranged metabolism, which is consistently associated with attempted adjustments of plants to environmental coincidences outside their accumulated experience, as this predisposing factor.

Major changes in environmental coincidences, in relation to individual plants may be the result of geographical distribution or of different dates of seeding in the same environment. The variability and instability of responses of plants under cultivation to specific environmental coincidences due to arbitrary dates of seeding, complicates the problem of plant distribution in relation to control of disease.

Optimum metabolism resulting from complete tolerance to environment would seem to insure freedom from physiological disturbances and give immunity from invasion by pathogenes. Susceptibility and resistance of plant to parasitic attacks appear to be in proportion to disturbance of metabolism.

Given a favourable host, parasitic disease will not develop except under a specific coincidence of host, pathogene, and environment favourable for development of pathogene and unfavourable for optimum metabolism of host.

Disease control through scientific plant distribution must be effected through reduction or elimination of occurrence of this essential coincidence.

Studies in crop distribution reveal a distinct relationship between geographical distribution of host and the incidence, type of expression and possibilities of control of specific plant disease.

Resistance of a host to a pathogene is relative and largely local, being the result of specific interrelationships of host, environment and pathogene. An individual plant or variety may possess immunity in one growth coincidence, varying degrees of resistance in others and extreme susceptibility in another. On the other hand, there is no definite association between a specific environment and incidence of disease except in relation to individual plants and varieties, as shown by the variability in incidence and expression of disease on different varieties in the same environment.

Species and varieties which have suffered widest distribution in proportion to limitations of natural habitat show greatest susceptibility to invasion by parasites. Likewise those improved commercial varieties developed under specific environmental coincidences by complex cross-breeding show greatest degree of metabolic disturbance under wide distribution and greatest variability in expression of pathogenic invasion.

Although the accumulated tolerance of a plant may render it adaptable to many growth coincidences, types of growth under different coincidences will be very dissimilar, and disturbances in metabolism will vary in physiological and morphological expression. The capacity of plants for variability in response to different coincidences within its accumulated experience, without deranging normal metabolism, must be considered in all seed distribution projects.

In view of the international aspects of the agricultural industry and the growing custom of distributing new varieties indiscriminately, some basis for international collaboration in ecological studies must be developed.

Breeding for resistance to disease must progress on a foundation of locally resistant strains, and all investigation must recognize the significance of a specific coincidence of host, pathogene and environment in relation to incidence of disease.

Indiscriminate distribution of so many new varieties is causing rapid increase in physiological forms of disease and is thus complicating investigations in diagnosis and control.

There is a great need for international standardization of nomenclature and definition of local environmental conditions as a basis for intelligent seed distribution.

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## CURRENT PUBLICATIONS

CANADIAN BOYS' AND GIRLS' CLUB NEWS. Published quarterly by the Canadian Council on Boys' and Girls' Club Work, 435 Confederation Building, Ottawa.

The first two numbers of this publication have been received. It consists of a four page sheet containing news items from various clubs throughout the Dominion. The purpose of the quarterly is to keep up interest amongst the boys and girls and to give some idea of the scope of the movement to the public in general. We note items from all the provinces, many of them giving accounts of very excellent work being done by local clubs. In an item under 'Editorial Comment' it is stated that, "Preliminary reports from all provinces indicate that the total number of Boys' and Girls' clubs in the Dominion this year is slightly in excess of the total for 1931, when there were 1257 clubs in operation. With conditions as they are the fact that club organization has been well maintained indicates that the constructive value of junior agricultural club work is receiving recognition." A name and slogan contest is under way in which valuable prizes are offered for the name which will most suitably indicate the Boys' and Girls' club work in Canada and a slogan which will express the objective of club work. The contest is open to club members only. The publication of this quarterly is under the direction of Mr. A. E. MacLaurin, Secretary of the Canadian Council on Boys' and Girls' Club Work. —H.L.T.

# APERCU HISTORIQUE SUR L'UTILISATION DE LA PAILLE ET SUR L'ETUDE DE SES CONSTITUANTS.

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## II. Etudes des Constituants de la Paille

Les méthodes d'analyse générale de la paille pour l'isolement de ses constituants ont été d'abord inspirées de celles de l'analyse du bois. Déjà en 1888, P.-P. Dehérain (*21*) s'occupe de l'isolement de la vasculose. Puis en 1890, A. Hébert (*41*) s'appuyant sur les travaux de Wheeler et Tollens (*122*), extrait la gomme de paille selon le mode opératoire suivant.

L'humidité, les cendres, les matières azotées, les matières solubles dans l'éther et dans l'eau, sont déterminées par les méthodes usuelles. Hébert recommande ensuite de dissoudre la vasculose et la gomme de paille en traitant par la soude à 10%, en tube scellé, la matière préalablement épuisée par l'éther et par l'eau; la dissolution n'est complète qu'après chauffage au bain d'huile à 120° pendant trois heures. Le contenu est alors étendu d'eau, puis filtré. Reste sur le filtre la cellulose.

La solution, neutralisée par HC1, est évaporée à sec au bain-marie; on reprend par l'eau. Après filtration, le résidu est identifié comme étant de la vasculose.

Le liquide filtré, concentré au bain-marie, additionné de HC1 à 5% est saccharifié en flacon bouché au bain de sel pendant deux heures. Le sucre obtenu est du xylose. On dose à la liquer de Fehling. On calcule ainsi la gomme de paille en xylose.

Il semble que depuis lors, les méthodes d'analyse générale n'aient pas été sensiblement modifiées, car la plupart des auteurs plus récents ont spécialement orienté leurs travaux vers l'extraction de la cellulose ou des autres constituants de la paille.

Voici quelques exemples d'analyses de paille.

| | | |
|---|---|---|
| Eau | 10,40 | |
| Matières azotées | 2,42 | N: 0,388% gr. |
| Matières solubles dans l'éther (matières grasses et résidus chlorophylliens) | 1,18 | |
| Matières solubles dans l'eau (cendres déduites, sucres non réducteurs, gommes et tannins) | 3,37 | |
| Cellulose | 33,60 | |
| Vasculose | 24,00 | |
| Gomme de paille (calculée en xylose) | 19,71 | |
| Cendres | 6,34 | |
| | 101,02 | |

Nos connaissances se sont cependant précisées, concernant en particulier la composition chimique de la partie inorganique de la paille (*40*) à la suite des travaux de T. W. Fagan et J. E. Watkin (*28*), à qui nous empruntons les chiffres ci-dessous:

| | |
|---|---|
| Huile | 1,41-1,99 |
| Albuminoides (bruts) | 2,66-3,28 |
| Albuminoides (vrais) | 2,49-3,06 |
| Fibre | 44,98-48,32 |
| Glucides solubles | 42,51-45,80 |
| Cendres | 4,40-4,52 |
| Cendres (libres de $SiO_2$) | 3,14-3,68 |
| $SiO_2$ | 1,14-1,72 |
| $P_2O_5$ | 0,126-0,174 |
| CaO | 0,427-0,520 |
| Cl | 0,408-0,648 |
| $Fe_2O_3$ | 0,019-0,029 |

Enfin, tout dernièrement, Arthur G. Norman (*80*) (1929), nous donne ses résultats sur la composition de la paille d'avoine et de seigle:

| | *Avoine* | *Seigle* |
|---|---|---|
| Cendres | 7,07 | 3,46 |
| Hémicelluloses libres | 22,80 | 33,40 |
| Cellulose pure | 43,80 | 46,53 |
| Xylane (dans la cellulose) | 9,30 | 8,34 |
| Pectine (pectate de Ca) | 1,10 | 0,34 |
| Protéines | 1,80 | 1,90 |
| Lignine | 18,50 | 19,50 |

1.—*Cellulose.*

En language industriel, le terme "cellulose" désigne généralement un résidu laissé après délignification par la méthode au chlore (*39*). En effet la composition chimique de la cellulose industrielle varie selon le procédé employé pour son extraction.

Parmi les méthodes générales d'extraction de la cellulose des tissus lignifiés, il convient de signaler tout d'abord celle de Cross et Bevan (*18*). Ces auteurs soumettent la matière sèche à l'action de la soude à 1%, et traitent ensuite le résidu, préalablement filtré et lavé, par un courant de chlore humide. Il se produit une chloruration de la lignine, laquelle est alors dissoute au moyen d'une solution de $Na_2SO_3$ à 2%, à chaud, et d'un peu de NaOH. On obtient sur le filtre la cellulose qui est lavée, blanchie, séchée et pesée.

C'est encore cette méthode qui, avec de légères modifications, donne les meilleurs résultats. Ces modifications ont été apportées par Renker (*88*), qui opère sur la matière humide, et traite par le chlore à froid, ainsi que par Schorger (*98*), Ritter et Feck (*91*), Sieber et Walter (*104*), Dore (*23*), etc.

Le grand avantage de ce procédé au chlore est d'enlever les substances incrustées et les polyholosides les moins stables, appelés par certains auteurs "hémicelluloses". Il est bien évident qu'un tel procédé ne peut donner un résidu toujours homogène, car la matière extraite dépend de la résistance des polyholosides renfermés dans diverses cellules.

Une autre méthode plus récente, employant $ClO_2$-$Na_2SO_3$ et pouvant rivaliser avec celle de Cross et Bevan, a été préconisée par E. Schmidt

(*97*). Le procédé Schmidt donne des résultats plus élevés en cellulose, mais Heuser, qui l'a étudié plus spécialement avec Merlau (*48*), constate qu'il ne donne pas encore une juste idée de la quantité totale des polysolosides contenus dans les membranes cellulaires, bien qu'il soit meilleur encore dans ce sens que les autres, et très pratique.

Bon nombre d'autres méthodes de moindre valeur ont été proposées, entre autres celles de Hugo Müller (*73*) à l'eau de brome, F. Schulze-Henneberg (*42*) au $KClO_3$ et $NO_3H$, Hoffmeister (*50*) au $KClO_3$ et HCl, Kalb et Schoeller (*57*) au Phénol.

Quant aux méthodes indirectes, elles ont surtout été employés par Becker et König (*5*). Ces méthodes consistent à soustraire de 100 les pourcentages de protéine, résine, cendre, lignine, hémicelluloses. Elles indiquent, en général, un chiffre beaucoup trop faible pour la cellulose.

De toutes ces techniques, aucune ne semble avoir été jusqu'ici appliquée à la paille. Dans ce domaine, en plus des méthodes d'analyse générale ou de fabrication de la pulpe citées plus haut, on peut rappeler quelques autres travaux.

Ainsi, T. Knosel (*61*) soumet la paille à une macération de deux à quatre heures dans une solution de soude à 25% portée à la température de 100°. Au cours de cette digestion, la plus grande partie de la gomme de paille, ainsi que des autres constituants non cellulosiques, passe en dissolution dans l'alcali. La partie fibreuse résiduelle, qui renferme la cellulose, est reprise par une solution de soude plus diluée (0,5-1%) et par le chlorure de calcium, pour être complètement débarrassée de la gomme et de la lignine qui l'imprègnent.

La solution de soude, selon sa concentration, selon le temps de contact ou la température de réaction, supprime plus ou moins complètement les matières non-cellulosiques, ainsi que le démontrent les résultats suivants, empruntés à un travail de Magnus (*67*) sur ce sujet.

Avec 12% de soude, et après 3 jours de contact, la paille perd 27% de son poids. La partie solubilisée a la composition suivante:

| | % | | % |
|---|---|---|---|
| Cendres | 1,1 | Cellulose | 1,6 |
| Mat. protéiques | 0,8 | Lignine | 13,8 |
| Pentosanes | 3.7 | | |

La proportion dissoute est de 47%, avec 8% de soude, à la température de 154°, après quatre heures de contact, et consiste en:

| | % | | % |
|---|---|---|---|
| Cendres | 1,6 | Cellulose | 7,6 |
| Mat. protéiques | 2,2 | Lignine | 18,7 |
| Pentosanes | 9,7 | | |

B. Dorner (*26*) reprend en détail l'étude de l'extraction à la soude, et, après avoir expérimenté plusieurs techniques, il recommande la suivante: La paille broyée, tamisée, et dépourvue des parties solubles dans l'eau chaude, est traitée par une solution alcaline à moins de 1%. La silice et les silicates s'y dissolvent en grande partie. Le résidu est soumis ensuite

à une seconde macération dans une solution d'alcali à 2%, qui entraine la partie non-cellulosique. Cette fois, ce qui reste est essentiellement constitué de pentosanes et de cellulose. Ces extractions peuvent être faites à chaud (*112*), ou encore s'effectuer sur une matière préalablement hydrolysée par l'acide sulfurique dilué (*20*), par une solution normale d'acide nitrique. En ce cas, l'hydrolyse élimine la plus grande partie des pentosanes.

Un autre procédé d'extraction de la cellulose, proposé il y a déjà quelques années, consiste à combiner l'action de la soude et celle du chlore. L'usage du chlore a pour effet d'activer la solubilisation des substances non-cellulosiques, et aussi d'assurer le blanchiment de la cellulose.*

E. Heuser et A. Hang, en 1918 (*46*), réussissent à retirer, par cette méthode, une proportion en cellulose de 54,75 à 55,60% du poids de la paille. Le produit ainsi obtenu renferme cependant une certaine quantité de pentosanes (*37*), ce qui en restreint l'usage au point de vue industriel (*82*).

On a aussi cherché à extraire la cellulose en utilisant le carbonate de soude, un lait de chaux (*83*) (*120*), le nitrate de baryum (*1*), mais les résultats ne semblent pas aussi satisfaisants au point de vue de la qualité de la cellulose extraite.

*Décomposition de la cellulose.*

Des organismes aérobies et certains champignons sont responsables de la décomposition de la cellulose en milieu humide et à une température assez élevée (50° semble être le maximum) (*76*). Chr. Barthel et N. Bengtsson (1926) (*3*) constatent que la cellulose à l'état combiné, comme dans la paille, est décomposée beaucoup plus rapidement que la cellulose libre (papier filtre); ce qui démontre que les matières azotées de la paille peuvent aider la décomposition. A. G. Norman (1929) (*79*) affirme que les substances susceptibles de donner du furfural ne semblent pas jouer un grand rôle dans le procédé de décomposition de la cellulose.

*Usage de la cellulose de paille.*

Les usages de la cellulose en général se multiplient de jour en jour. Quant à ceux de la cellulose de paille en particulier, bien qu'ils puissent être approximativement les mêmes, ils sont restreints actuellement, vu son prix élevé, à la fabrication du papier surtout (*89*) (*14*), ainsi que de la soie artificielle (*13*), des matériaux de construction (*127*), des pièces isolantes, de sucres (*33*) (*65*) (*107*).

*2.—Lignine.*

Dans l partie, dite lignifiée, des tiges végétables telles que la paille et le bois, il se trouve, associée à la cellulose et aux pentosanes, une substance, ou mieux un groupe de substances que l'on désigne sous le nom de lignine. C'est une matière amorphe, résineuse. Sa couleur varie du brun clair au noir selon le procédé qui a servi à son extraction.

L'isolement de la lignine se fait de plusieurs façons. On peut procéder directement, en l'isolant par des réactifs divers, ou indirectement, soit en calculant sa teneur par différence, soit par la détermination des groupes

* Le mécanisme des réactions mises en jeu par la méthode à la soude et au chlore fut spécialement étudié par J. Strachan (*108*).

méthoxylés. Aucune de ces façons de procéder ne donne de résultats tout à fait précis; mais dans l'état actuel de nos connaissances sur la chimie de la lignine, on ne peut désirer d'avantage.

Parmi les diverses méthodes proposées jusqu'ici, on distingue d'abord le procédé de Klason (*59*), qui consiste à traiter directement la substance par de l'acide sulfurique à 70%. Les polyholosides s'y dissolvent; la lignine reste insoluble. Ce procédé a été dans la suite légèrement modifié par König et Rump (*62*), Schwalbe et Becker (*102*), Dore (*23*), Mahood et Cable (*68*), von Euler (*118*). Willstatter et Zeichmeister (*123*) ont proposé l'emploi de HCl (d. 1,21) à la place de l'acide sulfurique et leur méthode fut adoptée par Krull (*63*), puis par Dore (*24*), qui en modifièrent légèrement l'application. Schwalbe (*102*) emploie six parties de $H_2SO_4$ à 72% pour une partie d'HCl à 18%.

Ross et Potter (*93*) font la détermination de la lignine au moyen de la formaldéhyde et de l'acide sulfurique.

Comme nous l'avons déjà vu, le traitement par la soude entraîne la plus grande partie de la lignine que l'on peut récupérer en neutralisant la solution alcaline (*51*).

D'autres méthodes ont aussi été proposées pour la détermination de la lignine. Plusieurs auteurs, ayant constaté la présence continuelle du groupe oxyméthylé dans la molécule de lignine, ont songé à doser la lignine par la quantité d'acide iodhydrique nécessaire à la fixation de ce groupe. Zeisel (126) fut l'un des initiateurs de cette méthode. Les résultats que l'on obtient ainsi sont loin d'être précis, puisqu'il a été démontré par Ritter (*90*), en particulier, que le nombre de groupes oxyméthylés associés à la lignine est variable selon la substance d'origine, et parfois variable aussi, pour une même plante, selon qu'il s'agit de la lignine de la lamelle moyenne, ou d'une autre région de la tige.

On peut encore déterminer le degré de lignification en multipliant par un facteur le poids du chlore absorbé par une quantité connue de bois, exempt d'humidité, et complètement dérésinifié (*119*).

On a utilisé aussi, pour l'isolement de la lignine, le phloro-glucinol (*15*) et l'acide nitrique (*103*).

De ces divers procédés, qui sont utilisés dans l'analyse du bois, aucun ne semble avoir été appliqué à la détermination quantitative de la lignine de la paille. .Sauf Hébert (*41*), Paschke (*82*), très peu de chimistes semblent s'être jusqu'ici préoccupés de cette question.

Il faut dire que toutes ces méthodes sont plus ou moins arbitraires et empiriques, car on ne connaît pas encore exactement la structure chimique de la lignine. Certains savants donnent à la lignine une structure cyclique ou hydro-cyclique (*109*). D'autres la classent parmi les polyholosides. En effet, après avoir considéré l'ensemble des travaux, on peut se demander si la composition de la lignine est homogène, comparable à celle de la cellulose, ou bien si elle est constituée par un mélange de diverses substances non glucidiques (*125*). Si les recherches sur la constitution de la lignine n'ont pas jusqu'ici donné plus de résultats, il faut surtout s'en prendre, d'après Schrauth (*99*), aux méthodes d'isolement. Selon cet auteur, la

lignine subit une certaine dégradation sous l'action des agents chimiques, de sorte que la matière isolée n'a pas la même constitution que celle que renferme la plante. C'est aussi l'opinion de Powell et Whittaker (*85*), qui se demandent même si, dans la plante, la lignine ne serait pas associée à des groupes acétylés ou à des pentosanes.

Concernant la structure de la lignine de la paille, il n'y a lieu de signaler qu'un travail, celui de Paschke (*83*), dans lequel il attribue la formule brute $C_{27}H_{31}O_9$, avec une concentration en oxygène supérieure à celle de la lignine du bois.

La lignine ne semble pas jusqu'ici avoir d'application industrielle bien importante. Elle est parfois associée à la cellulose dans la pulpe, mais on cherche à l'isoler la plupart du temps dans l'industrie du papier.

3.—*Hémicelluloses et Pentosanes.*

Schulze (*100*) donne le nom d'hémicelluloses aux polyholosides insolubles dans l'eau, mais solubles dans les alcalis et les acides et rapidement hydrolysées par ces derniers. Le terme "hémicelluloses" comprend entre autres les glucosanes, mannanes, lévulanes, galactanes, xylanes, arabanes et les composés tels que le mannogalactane, le xylomannane, etc.

On peut les considérer comme des glucides dont la grandeur moléculaire est intermédiaire entre celle de la cellulose vraie ou des substances de réserve comme l'amidon, les gommes et celles de leurs produits d'hydrolyse totale.*

Art. G. Norman (*10*) a fractionné de la façon suivante les hémicelluloses de la paille d'avoine et de seigle; et voici la composition trouvée par cet auteur:

| | | |
|---|---|---|
| Paille d'avoine | Hémicellulose A | 11% acide uronique (anhydride). |
| | | 79% arabinose et xylose. |
| | | 10% anhydrogalactose. |
| | Hémicellulose B | 68% arabinose. |
| | | 32% acide uronique (anhydride). |
| Paille de seigle | Hémicellulose A | 5% acide uronique (anhydride). |
| | | 60% anhydropentose. |
| | | 35% anhydrohexose. |
| | Hémicellulose B | 29% acide uronique (anhydride). |
| | | 60% anhydropentose. |
| | | 11% anhydrohexane. |

Parmi les constituants des hémicelluloses de la paille, ce sont les pentosanes qui ont été les plus étudiés.

L'analyse de la paille faite par A. Hébert en 1890 (*41*) permet d'extraire le xylose de la gomme de paille. Cependant cette méthode de préparation du xylose, dont il fut question plus haut, est jugée longue et pénible par G. Bertrand (*11*) qui, pour simplifier le travail, suggère

* Plusieurs chimistes, Heuser en particulier (*44*), recommandent d'abandonner ce terme "hémicelluloses" qui est bien indéfini, et basé uniquement sur quelques propriétés physiques ou chimiques.

d'opérer, non pas sur la gomme de paille, mais sur la paille elle-même, comme suit:

Après double macération dans l'eau tiède, la paille est chauffée avec 10 fois son poids d'eau, à .01 ou .02% d'acide sulfurique. Après quelques heures d'ébullition, la masse est pressée. L'acide de la liqueur obtenue est séparé par la baryte; puis on reprend par l'alcool, on décante et on distille. Ces opérations donnent un sirop jaune qui cristallise rapidement lorsqu'il est amorcé de quelques cristaux de xylose. On purifie par cristallisation dans l'alcool bouillant à 95°.

E. Salkowski, en 1901 (*96*) procède encore différemment, il isole d'abord le xylane de la paille de froment, qu'il transforme ensuite en xylose par hydrolyse. Pour cela, il fait bouillir 100 grs de paille avec 2.5 litres de NaOH à 6%, pendant 45 minutes. Il clarifie et précipite le xylane (l'arabane restant en solution), pr la liqueur de Fehling à feu doux. Le précipité est traité par HCl dilué, puis plusieurs fois par l'alcool et l'éther. Pour purifier, il recommence l'opération. Il obtient un rendement brut de 22-23% de xylane, contenant encore un peu de cellulose. Il hydrolyse par $H_2SO_4$ à 5%.

En simplifiant la méthode de Salkowski, E. Heuser (*43*) 1921, a obtenu un excellent rendement en xylane, contenant moins d'impuretés. Il a retiré de 300 grs de pulpe de paille blanchie, une proportion de 21-22% d'un produit renferment à l'analyse 96% de xylane pure (calculé en xylose), et 0,35% de cendres.*

Cet auteur effectue l'hydrolyse de la paille par l'acide chlorhydrique (d. 1,212 à 15°) et la détermination du xylose par le polarimètre, conformément à la méthode de R. Willstatter et L. Zechmeister (1913) (*124*). Il neutralise l'acide par $PbCO_3$, purifie par fractionnement à l'alcool, puis concentre jusqu'à sirop épais; la cristallisation s'opère après 3 semaines. Après une seconde cristallisation, le rendement en xylose est de 54,7% du poids des sirops.

L'année suivante (1922), E. Heuser et M. Brader (*45*) déterminent la présence de méthylxylane à l'état de phloroglucide méthylfurfural (*114*), lequel est soluble dans l'alcool. Ces auteurs jugent la méthode de Salkowski pour l'extraction du xylane peu économique. C'est pourquoi ils recommandent un autre procédé, qui consiste à précipiter dans la soude alcoolique le xylane au moyen de HCl.

Les pentosanes de la paille, bien que n'ayant pas jusqu'ici de débouché industriel très important, peuvent être utilisés selon Dorner (*26*), comme substance alimentaire, et même pour la production d'alcool.

Quant aux hémicelluloses totales de la paille elles donnent, lorsqu'elles sont soumises à l'hydrolyse acide, des produits susceptibles de fermenter sous l'action de bactéries pour se transformer aussi en alcool.

C'est ainsi que A. C. Thaysen et L. D. Galloway (*111*), ont obtenu 16 gallons d'un mélange d'alcool-acétone à partir d'une tonne de paille.

* D'après Haug (1925), la paille peut contenir jusqu'à 14.85% de xylane, susceptible d'être extrait par la soude; elle retient après la meilleure extraction possible, 9,01% de pentosane, qui selon cet auteur est aussi du xylane (*38*).

Il résulte de ces considérations que les utilisations que l'on a faites jusqu'ici de la paille, brute ou traitée, soit comme engrais, soit comme fourrage, sont loin de donner les résultats que l'on est en droit d'attendre d'un sous-produit aussi abondant.

Quant aux autres usages, ils sont assez secondaires, et pour la plupart encore peu économiques.

Aussi, malgré tous les résultats énumérés au cours de cette revue, il semble bien qu'une bonne partie de cette étude de la paille doive être reprise sur une base plus scientifique et plus économique, en particulier en ce qui concerne l'isolement et la purification des constituants, leur décomposition et la nature des agents de décomposition qui entrent en jeu au cours de l'action biochimique.

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# RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

La Preservation des Blocs-Echantillons de Sol. F. F. Morwick, Collège Agricole de l'Ontario, Guelph, Ont.

Une section verticale du sol est finement arrosée d'une solution de silicate de soude. On laisse sécher la surface pendant 24 heures puis on la couvre de goudron fondu et l'on place sur cette surface une planche elle-même recouverte de goudron fondu. On coupe alors en place la portion de sol ainsi préparée et l'on obtient de cette façon une mince section verticale de sol solidement attachée à la planche, la couleur et la forme étant préservées par le silicate de soude.

Pertes de matieres minerales par drainage dans certains sols de l'Alberta. Alfred Leahey, Université de l'Alberta, Edmonton, Alta.

Les divers horizons représentant les sols bruns, noirs et gris des ceintures forestières ont été analysés au point de vue de la silice, l'aluminium, le fer, le calcium, le magnésium et le phosphore.

L'analyse montre que dans les sols bruns ces éléments ne sont presque pas perdus par drainage. Dans les sols noirs il y a perte de chaux mais pour ainsi dire aucun déplacement d'aluminium ou de fer. Dans les sols forestiers gris il y a perte de chaux sur une profondeur considérable et grand déplacement d'aluminium et de fer.

Les sols forestiers gris sont les seuls sols dans lesquels il y ait une perte importante par drainage.

Les sols de l'Alberta se classent aisément dans le cadre du système russe de classification.

La Valeur des Differences de Poids Dans Les Experiences de Nutrition. E. W. Crampton, Macdonald College, P.Q.

Cet article décrit une nouvelle méthode d'analyse des résultats statistiques d'essais comparés de nutrition animale.

Les tableaux 1 et 2 forment la partie principale de l'article. Ile montrent clairement qu'avec un faible nombre d'animaux comme base d'expérience les différences trouvées doivent être élevées pour signifier quelque chose. La différence peut être de plus en plus faible et garder la même valeur au fur et à mesure que le nombre d'animaux augmente. Ces tableaux sont d'une grande valeur pratique en ce qu'ils permettent à l'éleveur de voir d'un coup d'oeil et sans avoir à faire de calculs quelle différence il doit obtenir dans une expérience de nutrition pour qu'elle soit concluante.

Commentaires Sur la Depreciation et Les Reparations des Moissoneuses Combinees et des Tracteurs dans les Provinces des Prairies. E. G. Gresy, Université de la Saskatchewan, Saskatoon, Sask.

Cet article concerne la comptabilité des exploitations agricoles de l'Ouest. Des tableaux indiquent la dépréciation des combines et des tracteurs sans qu'il soit besoin de faire de calculs.

Au Sujet du Controle des Maladies des Plantes. Tennyson D. Jarvis, Ontario Research Foundation, Toronto, Ont.

La sélection naturelle a produit des plantes bien adaptées à un certain milieu. Le pépiniériste, par le croisement de ces variétés naturelles avec des variétés cultivées et par leur introduction dans un nouveau milieu, dérange la capacité naturelle de résistance des plantes aux maladies de leur milieu primitif. L'auteur préconise une étude complète des différents facteurs qui créent le "milieu" et la création de cartes de "coïncidences régionales" comme base au développement de nouvelle variétés.

# CONCERNING THE C.S.T.A.

## NOTES AND NEWS

H. E. LEFÈVRE

H. E. Lefèvre, Treasurer and General Manager of the Potash Company of Canada Limited and French Secretary of the Canadian Society of Technical Agriculturists, has been made Chevalier du Mérite Agricole. This honour was conferred on Mr. Lefèvre by the French Minister of Agriculture for services rendered to agriculture by a decision dated March 15th, 1932. Members of the Society will join in congratulating their French Secretary on this high honour.

A. J. Charnetski, (Alberta '30) who has been located at Edmonton, is now District Agriculturist at Myrnam, Alberta.

A. J. Cooper, (Manitoba '31) has accepted a position with the Indian Residential School at Brandon, Manitoba.

V. S. Asmundson, (Saskatchewan '18) formerly Associate Professor of Poultry Husbandry at the University of British Columbia, has accepted a position as Research Associate at the University of California, Berkeley.

W. C. Hopper, (Toronto '20) who has been doing post-graduate work in the Department of Agricultural Economics at Cornell University, has received his Ph.D. degree and has accepted a position on the Faculty of the State College of Agriculture, at Cornell University. Working with Dr. G. T. Warren and his associates, Dr. Hopper majored in marketing with minors in farm management, general agricultural economics, and agronomy.

James Marshall, (Washington '29) is now Assistant Entomologist at the Washington Experiment Station, Courthouse, Wenatchee, Wash.

W. E. Senn, (Toronto '23) formerly with the Border Chamber of Commerce, Windsor, is now located at Wellandport, Ont.

H. E. Davey, (Toronto '28) is now at the University of California, Berkeley, where his address is 107 Hilgard Hall.

Joseph G. Morgan, formerly of Amherst, N.S., died on June 29th. Members who desire to express their sympathy to Mrs. Morgan may address her at 126 Church St., Amherst, N.S.

W. K. Smith, (Aberdeen '23) has moved from Pullman, Washington, to the Department of Genetics, University of Wisconsin, Madison, where he holds a Fellowship under the United Stated National Research Council.

R. F. Peterson, (Manitoba '30) who has been taking post-graduate work at the University of Minnesota, has returned to the Dominion Rust Research Laboratory, Winnipeg, Man.

Robert Newton, (McGill '12) formerly Professor of Field Crops and Plant Biochemistry, at the University of Alberta, has moved to Ottawa to take up his work as Director of the Division of Biology and Agriculture of the National Research Council. Dr. Newton's house address will be 25 Buena Vista Road, Rockcliffe Park, Ottawa.

C. E. Ste. Marie, (McGill '28) who has been taking post-graduate work in Economics at Cornell University, has resumed his duties as Supervisor of Illustration Stations for Central Quebec and Lake St. John with headquarters at the Central Experimental Farm, Ottawa.

The General Secretary, H. L. Trueman, is taking a hurried trip to the Maritime Provinces following the death of his father-in-law, Mr. Herbert C. Lewis of Yarmouth, N.S. No C.S.T.A. meetings are being arranged during the trip but the General Secretary expects to visit as many of the Society officers as possible and will probably be at Fredericton, Charlottetown, Truro and Halifax.

# NATIONAL ADVISORY COMMITTEE ON AGRICULTURAL SERVICES

H. L. Trueman

The National Agricultural Conference held during the week of August 29th in Toronto under the leadership of the Hon. Robert Weir, Federal Minister of Agriculture, was entirely successful in accomplishing the two main purposes for which it was called. The conference succeeded in agreeing on general methods of attack on some of the main problems of Canadian agriculture, and it also set up a permanent agency for the purpose of co-ordinating services. In this latter achievement, it accomplished more than any previous conference of a similar nature, and there is, therefore, more reason to hope that a distinct advance has been made toward fitting the various agricultural services into a national programme.

The conference was attended by all the Ministers of Agriculture, all but two of the Deputy Ministers, all the heads of Agricultural and Veterinary Colleges, most of the branch chiefs of the Dominion Department of Agriculture and the divisional chiefs of the Experimental Farms System, and representatives of the provincial Research Foundations, the National Research Council, the Dominion Board of Grain Commissioners, the Dominion Bureau of Statistics, the Canadian Society of Technical Agriculturists, the Canadian National Railways, the Canadian Pacific Railway, and by other senior officials attached to the above services.

A mimeographed agenda giving an outline of the purpose of the conference had been prepared by the officials of the Dominion Department of Agriculture in co-operation with the executive of the C.S.T.A. The need for the formation of a national committee was set forth as follows:

"The desirability of close co-operation between all governmental and institutional agencies serving agriculture is beyond question. It is recognized that an increasing amount of co-operation has developed during the past few years, particularly between men closely associated with one another around particular problems and projects. The first purpose of this conference is to set up a national committee which will be charged with the task of co-ordinating the work of those co-operative agencies already in existence and of recommending the organization of new co-operative bodies where necessary. While this will not achieve at a single stroke that complete co-ordination of governmental services desired, it will provide the machinery for immediate co-ordination on many projects. Under existing conditions the best policy would seem to be to work from the ground up through the provincial joint committees and smaller group organizations of technical men themselves, endeavouring by means of a national committee to co-ordinate and extend their efforts as far as possible and at the same time to evolve broader principles of co-operative effort upon which it may be possible to build an ultimate co-ordination of the whole."

A list of those organizations already in existence which could function through a national committee was attached. This included many joint committees, associate committees, and professional societies all doing valuable work but lacking a co-ordinating medium.

The discussion of major problems of Canadian agriculture occupied the most of the time. Each subject was introduced by leading federal and provincial officials who confined themselves mainly to national considerations. Committees of the conference were appointed to draft reports on each of these major problems, giving particular emphasis to what agricultural services were involved and what general principles should be followed in an attack on these problems. General discussions took place until Wednesday noon and committees met to complete their reports Wednesday afternoon and evening. Committee reports were mimeographed Wednesday night and laid before the conference Thursday morning.

It was found that the committees had in all cases succeeded in developing a national view-point. Report after report proceeded to lay down fundamental principles of procedure for various services, and the need for a national body to co-ordinate the whole complex machinery became more and more apparent as

the reports were read. It should be kept in mind that the reports were "accepted" and not "adopted". This is a distinction which will probably be maintained throughout future deliberations of the National Advisory Committee. Technical men sitting on a committee on one particular line of work were supposed to be able to bring in a report representing the best ideas in that field. Occasionally an addition or slight modification was suggested by the conference and the report was then accepted. The recommendations contained in these reports are to be laid before administrative officers and their Ministers who will, of course, determine whether the recommendations are in the best interests of the farmers of their respective provinces or not. The general unanimity with which reports were received, however, and the confidence which the various Ministers expressed in the soundness of the recommendations made by the leading technical agriculturists of the Dominion guarantee that action on many important problems will follow almost immediately. In fact, one feature of the conference was that several smaller regional conferences, out of which direct action will take place, proceeded on the side between Ministers and their advisors. This should always be an important feature of future annual meetings and is well worth while in itself.

On the last day of the conference, the delegates, having been impressed with the need for a national body, proceeded to discuss the proposal for a National Advisory Committee. Discussion was frank and free, and when it became apparent that the setting up of such a body might be misinterpreted as a move on the part of the technical men to usurp power which did not belong to them, action was taken to guard against the possibility of such misunderstanding in the future. Accordingly the following resolution was unanimously adopted:

I. This Conference recommends the formation of a National Committee on Agricultural Services composed of the Federal Minister of Agricultural as Chairman and the nine Provincial Ministers of Agriculture.

It is also recommended that this body shall have as a National Advisory Committee on Agricultural Services the following: The Federal Deputy and Assistant Deputy Ministers of Agriculture, the nine Provincial Deputy Ministers of Agriculture, the heads of the Agricultural and Veterinary Colleges, representatives of the Provincial Research Foundations, National Research Council, Dominion Bureau of Statistics, Dominion Board of Grain Commissioners, Canadian Pacific Railway, and such other representatives as the National Committee on Agricultural Services may nominate.

II. This Conference also recommends the formation of a Provincial Advisory Committee on Agricultural Services in each Province, such a Committee to be under the Chairmanship of the Provincial Minister of Agriculture.

Several of the provincial Ministers of Agriculture expressed their intention of calling provincial conferences in the near future. The work of existing committees and organizations will be reviewed and new committees formed where necessary. Details or organization of the National Advisory Committee will be worked out at an early date, incorporating modifications made at the national conference and other constructive ideas which may be suggested at provincial conferences.

During the discussion of important problems in Canadian agriculture one could not help but mark the friendly spirit which prevailed. The Hon. Mr. Weir in summing up the achievements of the week expressed the attitude of all when he said:—

"These questions have been before all our minds or else we would not have been so much in agreement in the discussion of them. We are here with the same purposes, each vitally interested and equally interested. If we do nothing else but leave this conference, each one of the whole army of agricultural workers realizing that we are one body, that we are not critical one of the other, but that the federal man in each province must be as loyal to the provincial man engaged in agricultural service and to the provincial college as he is to his own work, no man, not even the most optimistic of us, can begin to appreciate the great value of this conference.

What are some of the things that we may get behind? I have followed very closely all the discussions, and particularly the concentrated reports that have been submitted after careful work by the committees.

Are we agreed on this? That there is one subject which we can all get behind and preach in season and out of season, especially in view of the happenings that have taken place in Ottawa during the past month, namely, the question of standards. Take every opportunity that we can when coming in contact with other persons, or where it will have any effect, and preach the importance of a high standard that will be worthy of the intelligence of the farmers and of the people associated in agricultural work in this great and young Dominion. Are we agreed that this is a safe thing for everyone engaged in agricultural services to get behind? I think it needs no answer, because there is only one.

Are we also agreed that we should use every opportunity to focus the attention of the great body of farmers on weeds? It is not a matter just of research work on weeds. It is more a matter of personal contact, trying in every way that we can to encourage the farmer to use the things that he does know and that have been put within his reach. Are we agreed that this is another problem that we can attack, irrespective of any policy that may be laid down? We can unite on that whether we are engaged in work for agricultural colleges or otherwise.

The junior farmer work has been well emphasized. We would have done well, perhaps, to have put some time on a discussion of it. A few of us who have been closely studying the trend of agricultural development and progress have been very much impressed by the excellent system which has grown up, a system which is so valuable for our use in the building of agriculture on a sound foundation. We should put forth every effort that we can and assist in every way we can the junior farmer movement.

There is another question, that of marketing. Are we agreed that we have given too much attention to some of the questions of production, and not enough to the question of marketing? I would like to see in every junior farmer club in Canada, in every agricultural college, in every group or institutional meeting, some definite, direct, indisputable contribution made to this question of marketing. I feel in Canada one thing is needed more than anything else in the way of agriculture, and that is a farm marketing consciousness which would induce the farmers themselves to think on these problems of marketing, and learn what they themselves by their own operations can contribute to assist in the marketing of their own products.

We have spent, to me, four delightful days. After our somewhat hectic time at the Imperial Conference I was very tired. I wished that I had postponed this meeting for another week. And, although we have been engaged here in intensive work, I must say that the refreshing nature of the discussions on every problem before us has left me rested, absolutely rested, in a way that I would not have been, perhaps, if I had been engaged in other or more routine work.

There is one other point on which I would like to touch, and I think I but voice the opinion which predominates in the minds of all who are assembled here since this conference started, and that is that we owe much of the success of this conference to the efforts of a splendid group of men who belong to an organization which has existed in Canada for a number of years, the Canadian Society of Technical Agriculturists. It is the natural outcome of a desire on the part of their members throughout Canada—without much leadership, I regret to say, so far as we of governments are concerned—but just a desire in their attitude towards their work alone, that they should meet with other men in different spheres to discuss their common problems. There is, surely, nothing finer can be said of the technical agriculturists in Canada than that they, of themselves, with a love for the work, went on their own and for years have carried on this excellent organization which I believe has contributed more than anything else to the success and spirit that have prevailed throughout this conference."

During the conference Dr. E. S. Archibald, Director of the Dominion Experimental Farms System, acted as Chairman by agreement of the Ministers of

Agriculture. Dr. G. I. Christie, President of the Ontario Agricultural College, took his place during one session. The secretariat consisted of H. L. Trueman, General Secretary of the C.S.T.A., L. S. McLaine, Dominion Entomological Branch, and R. Whitman, Dominion Publications Branch, with the able assistance at various times of many members of the conference. The Press committee included Dr. A. T. Charron, Dominion Deputy Minister, J. B. Fairbairn, Deputy Minister for Ontario and L. S. McLaine, Dominion Entomological Branch.

Dr. Archibald speaking from the Chair at the close of the conference expressed the feeling of the technical men present when he stated:

"I presume that a motion for adjournment is about in order, but before that is introduced I hope you will first allow me a few sentences in which to express the opinion of a large number of the older employees of governments in this room.

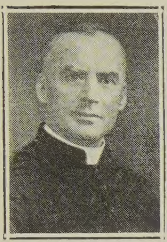
We have, over a period of fifteen or twenty years, Hon. Mr. Weir and gentlemen, attended many conferences of this kind. Some of them, I think, had slight benefits. Most of them have been wash-outs. This year, with the able guidance of the Honourable Ministers, and with a clear objective in mind, we go back to our several offices—for after all we are practically all administrative officers, either in one field or another—we go back to our staffs having achieved the objectives which were so clearly outlined by the Hon. Mr. Weir in his opening remarks. We have a general concensus of opinion as to what are the major opportunities and needs in agriculture; we have agreed upon these, and we have had the opinion of our respective Ministers. In the setting up of a national organization we now have something more definite through which to work, machinery by which we can more closely co-ordinate our efforts. These are things that we who attended conferences in years gone by never received.

On behalf of all federal and provincial workers, all the C.S.T.A. members, all who are striving to do something for agriculture, we just wish to compliment the several Ministers for the lead, the spirit of confidence, which marks our determination to go home and work along united lines. Because of the fact that this conference came to a definite conclusion, departmental workers, not only those whom you see here but the thousand other officers who are under us at home, will be encouraged to greater and more effective effort, and you will never be able to estimate just what you have done to the united services of departments of agriculture, and others, throughout Canada."

*The monument erected to the mémory of l'abbé Pilote, founder of the School of Agriculture, Ste-Anne de la Pocatière.*

## HISTORIC OCCASION AT QUEBEC AGRICULTURAL COLLEGE

On May 25, 1932, there was unveiled at Ste. Anne de la Pocatière a monument to the honour of l'Abbé Francois Pilote, founder of the School of Agriculture now affiliated with Laval University. The school opened ist doors in the autumn of 1859 antedating the Ontario Agricultural College at Guelph by fifteen years. During the first few years of its existence pupils were not numerous, but by the time it celebrated its fiftieth anniversary it had turned out over five hundred graduates.

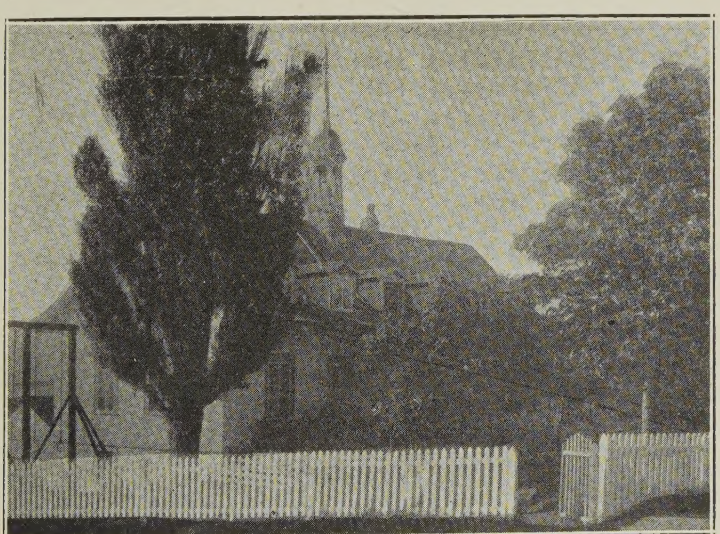


L'ABBE HONORIUS BOIS, *Director of the School of Agriculture, Ste-Anne de la Pocatière.*

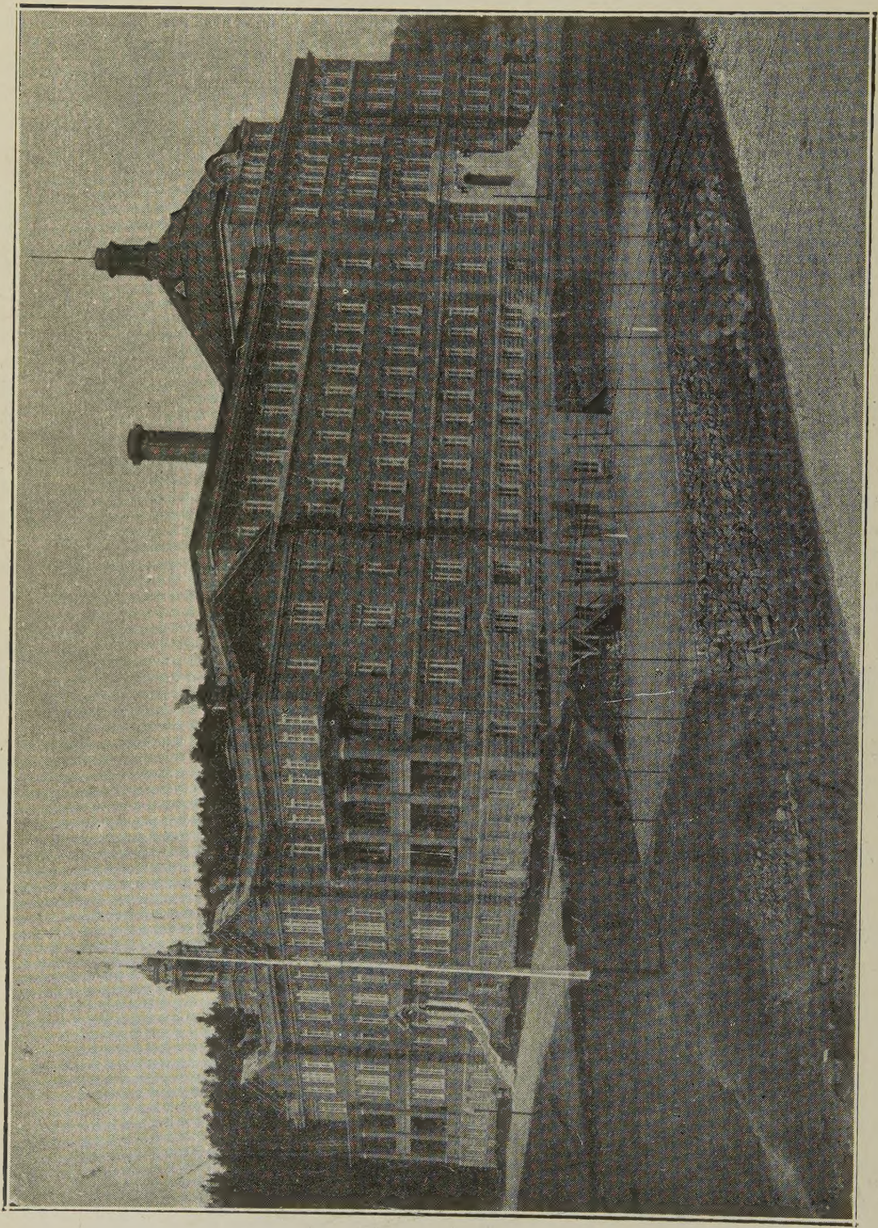
In 1912 it was moved to its present location in connection with the College of Ste. Anne de la Pocatière and in 1915 two wings were added to the main building. The school was completed in 1931 with accommodation for 225 pupils. The institution gives a four year course leading to the degree of B.S.A. which is granted by Laval University. It gives also an associate course of two years and several short courses each winter.

The ceremonies attending the consecration of the new building and the unveiling of the monument to l'Abbé Pilote were attended by many of the state and church dignitaries of the province. The consecration of the new sections of the building was performed by His Excellency Monsignor Villeneuve, Archbishop of Quebec, and the monument was unveiled by the Hon. Adelard Godbout, Minister of Agriculture and President of the Alumni Association. His Excellency, the Hon. G. Carroll, Lieutenant Governor, addressed the assembly on "The Importance of Agriculture from the Social Point of View." L'abbé H. Bois, Director of the School of Agriculture, was given the degree of Doctor of Science in Agriculture by Monsignor Pelletier, Rector of Laval University. The entire ceremony was in keeping with the motto of the school, "The soil is the homeland"—improve the one and you serve the other.

Members of the C.S.T.A. throughout Canada joined with their colleagues in Quebec in honoring l'abbé Honorius Bois by making him a fellow of the Canadian Society of Technical Agriculturists. This action was taken unanimously at the recent convention in Winnipeg in appreciation of the great service already rendered to Canadian agriculture by l'abbé Bois.



*The School of Agriculture, Ste.-Anne de la Pocatière in 1859.*



*The School of Agriculture, Ste-Anne de la Pocatière, in 1931.*